IN THE UNITED STATES BANKRUPTCY COURT
SOUTHERN DISTRICT OF NEW YORK

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	:	
In re	:	Chapter 11
	:	
DELPHI CORPORATION, et al.,	:	Case No. 05-44481 (RDD)
	:	
Debtors.	:	(Jointly Administered)
	:	
- -	x	

AFFIDAVIT OF SERVICE

I, Evan Gershbein, being duly sworn according to law, depose and say that I am employed by Kurtzman Carson Consultants LLC, the Court appointed claims and noticing agent for the Debtors in the above-captioned cases.

On July 13, 2007, I caused to be served the documents listed below (i) upon the parties listed on Exhibit A hereto via overnight delivery, (ii) upon the parties listed on Exhibit B hereto via electronic notification and (iii) upon the parties listed on Exhibit C hereto via postage pre-paid U.S. mail:

1) Notice Of Presentment Of Joint Stipulation And Agreed Order Compromising And Allowing Proof Of Claim Number 8914 (Klash, Inc.) (Docket No. 8598) [a copy of which is attached hereto as Exhibit D]

2) Notice Of Presentment Of Joint Stipulation And Agreed Order Compromising And Allowing Proof Of Claim Number 2440 (Sierra Liquidity Fund, LLC As Assignee Of Applied Tech Industries, Inc.) (Docket No. 8604) [a copy of which is attached hereto as Exhibit E]

3) Notice Of Presentment Of Joint Stipulation And Agreed Order Compromising And Allowing Proof Of Claim Number 14663 (Sierra Liquidity Fund, LLC, As Assignee Of Fair-Rite Products Corporation) (Docket No. 8605) [a copy of which is attached hereto as Exhibit F]

4) Notice Of Presentment Of Joint Stipulation And Agreed Order Compromising And Allowing Proof Of Claim Number 9402 (Bona Vista Programs, Inc.) (Docket No. 8607) [a copy of which is attached hereto as Exhibit G]

5) Notice Of Further Adjournment Of Claims Objection Hearing With Respect To Debtors' Objection To Proofs Of Claim Nos. 837 And 838 (H.E. Services Company And Robert Backie) (Docket No. 8615) [a copy of which is attached hereto as Exhibit H]

On July 13th, 2007, I caused to be served the documents listed below (i) upon the parties listed on Exhibit I hereto via overnight delivery and (ii) upon the parties listed on Exhibit J hereto via electronic notification:

6) Debtors' Objection To Robert Bosch GmbH's Motion To Amend Proof Of Claim (Docket No. 8618) [a copy of which is attached hereto as Exhibit K]

7) Declaration Of William Cosnowski, Jr. In Support Of Debtors' Objection To Robert Bosch GmbH's Motion To Amend Proof Of Claim ("Cosnowski Declaration - Objection To Bosch Motion") (Docket No. 8619) [a copy of which is attached hereto as Exhibit L]

On July 13th, 2007, I caused to be served the document listed below upon the party listed on Exhibit M hereto via overnight delivery:

8) Notice Of Presentment Of Joint Stipulation And Agreed Order Compromising And Allowing Proof Of Claim Number 8914 (Klash, Inc.) (Docket No. 8598) [a copy of which is attached hereto as Exhibit D]

On July 13th, 2007, I caused to be served the document listed below upon the parties listed on Exhibit N hereto via overnight delivery:

9) Notice Of Presentment Of Joint Stipulation And Agreed Order Compromising And Allowing Proof Of Claim Number 2440 (Sierra Liquidity Fund, LLC As Assignee Of Applied Tech Industries, Inc.) (Docket No. 8604) [a copy of which is attached hereto as Exhibit E]

On July 13th, 2007, I caused to be served the document listed below upon the parties listed on Exhibit O hereto via overnight delivery:

10) Notice Of Presentment Of Joint Stipulation And Agreed Order Compromising And Allowing Proof Of Claim Number 14663 (Sierra Liquidity Fund, LLC, As Assignee Of Fair-Rite Products Corporation) (Docket No. 8605) [a copy of which is attached hereto as Exhibit F]

On July 13th, 2007, I caused to be served the document listed below upon the party listed on Exhibit P hereto via overnight delivery:

11) Notice Of Presentment Of Joint Stipulation And Agreed Order Compromising And Allowing Proof Of Claim Number 9402 (Bona Vista Programs, Inc.) (Docket No. 8607) [a copy of which is attached hereto as Exhibit G]

On July 13th, 2007, I caused to be served the document listed below upon the party listed on Exhibit Q hereto via overnight delivery:

12) Notice Of Further Adjournment Of Claims Objection Hearing With Respect To Debtors' Objection To Proofs Of Claim Nos. 837 And 838 (H.E. Services Company And Robert Backie) (Docket No. 8615) [a copy of which is attached hereto as Exhibit H]

Dated: July 20, 2007

/s/ Evan Gershbein
Evan Gershbein

State of California
County of Los Angeles

Subscribed and sworn to (or affirmed) before me on this 20th day of July, 2007, by Evan Gershbein, personally known to me or proved to me on the basis of satisfactory evidence to be the person who appeared before me.

Signature: *\/s/ Shannon J. Spencer*

Commission Expires: *6/20/10*

EXHIBIT A

Delphi Corporation
Master Service List

COMPANY	CONTACT	ADDRESS1	ADDRESS2	CITY	STATE	ZIP	PHONE	FAX	EMAIL	PARTY / FUNCTION
Brown Rudnick Berlack Israels LLP	Robert J. Stark	Seven Times Square		New York	NY	10036	212-209-4800	212-2094801	rstark@brownrudnick.com	Indenture Trustee
Cohen, Weiss & Simon	Bruce Simon	330 W. 42nd Street		New York	NY	10036	212-356-0231	212-695-5436	bsimon@cwsny.com	
Curtis, Mallet-Prevost, Colt & mosle LLP	Steven J. Reisman	101 Park Avenue		New York	NY	10178-0061	2126966000	2126971559	sreisman@cm-p.com	Counsel to Flextronics International, Inc., Flextronics International USA, Inc.; Multek Flexible Circuits, Inc.; Sheldahl de Mexico S.A.de C.V.; Northfield Acquisition Co.; Flextronics Asia-Pacific Ltd.; Flextronics Technology (M) Sdn. Bhd
Davis, Polk & Wardwell	Donald Bernstein Brian Resnick	450 Lexington Avenue		New York	NY	10017	212-450-4092 212-450-4213	212-450-3092 212-450-3213	donald.bernstein@dpw.com brian.resnick@dpw.com	Counsel to Debtor's Postpetition Administrative Agent
Delphi Corporation	Sean Corcoran, Karen Craft	5725 Delphi Drive		Troy	MI	48098	248-813-2000	248-813-2491	sean.p.corcoran@delphi.com karen.j.craft@delphi.com	Debtors
Electronic Data Systems Corp.	Michael Nefkens	5505 Corporate Drive MSIA		Troy	MI	48098	248-696-1729	248-696-1739	mike.nefkens@eds.com	Creditor Committee Member
Flextronics International	Carrie L. Schiff	305 Interlocken Parkway		Broomfield	CO	80021	303-927-4853	303-652-4716	cschiff@flextronics.com	Counsel to Flextronics International
Flextronics International USA, Inc.	Paul W. Anderson	2090 Fortune Drive		San Jose	CA	95131	408-428-1308		paul.anderson@flextronics.com	Counsel to Flextronics International USA, Inc.
Freescale Semiconductor, Inc.	Richard Lee Chambers, III	6501 William Cannon Drive West	MD: OE16	Austin	TX	78735	512-895-6357	512-895-3090	trey.chambers@freescale.com	Creditor Committee Member
Fried, Frank, Harris, Shriver & Jacobson	Brad Eric Sheler Bonnie Steingart Vivek Melwani Jennifer L Rodburg Richard J Slivinski	One New York Plaza		New York	NY	10004	212-859-8000	212-859-4000	rodbuje@ffhsj.com sliviri@ffhsj.com	Counsel to Equity Security Holders Committee
FTI Consulting, Inc.	Randall S. Eisenberg	3 Times Square	11th Floor	New York	NY	10036	212-2471010	212-841-9350	randall.eisenberg@fticonsulting.com	Financial Advisors to Debtors
General Electric Company	Valerie Venable	9930 Kincey Avenue		Huntersville	NC	28078	704-992-5075	866-585-2386	valerie.venable@ge.com	Creditor Committee Member
Groom Law Group	Lonie A. Hassel	1701 Pennsylvania Avenue, NW		Washington	DC	20006	202-857-0620	202-659-4503	lhassel@groom.com	Counsel to Employee Benefits
Hodgson Russ LLP	Stephen H. Gross	1540 Broadway	24th Fl	New York	NY	10036	212-751-4300	212-751-0928	sgross@hodgsonruss.com	Counsel to Hexcel Corporation
Honigman Miller Schwartz and Cohn LLP	Frank L. Gorman, Esq.	2290 First National Building	660 Woodward Avenue	Detroit	MI	48226-3583	313-465-7000	313-465-8000	fgorman@honigman.com	Counsel to General Motors Corporation
Honigman Miller Schwartz and Cohn LLP	Robert B. Weiss, Esq.	2290 First National Building	660 Woodward Avenue	Detroit	MI	48226-3583	313-465-7000	313-465-8000	rweiss@honigman.com	Counsel to General Motors Corporation
Internal Revenue Service	Attn: Insolvency Department	477 Michigan Ave	Mail Stop 15	Detroit	MI	48226	313-628-3648	313-628-3602		Michigan IRS
Internal Revenue Service	Attn: Insolvency Department, Maria Valerio	290 Broadway	5th Floor	New York	NY	10007	212-436-1038	212-436-1931	mariaivalerio@irs.gov	IRS
IUE-CWA	Conference Board Chairman	2360 W. Dorothy Lane	Suite 201	Dayton	OH	45439	937-294-7813	937-294-9164		Creditor Committee Member
Jefferies & Company, Inc,	William Q. Derrough	520 Madison Avenue	12th Floor	New York	NY	10022	212-284-2521	212-284-2470	bderrough@jefferies.com	UCC Professional
JPMorgan Chase Bank, N.A.	Richard Duker	270 Park Avenue		New York	NY	10017	212-270-5484	212-270-4016	richard.duker@jpmorgan.com	Prepetition Administrative Agent
JPMorgan Chase Bank, N.A.	Susan Atkins, Gianni Russello	277 Park Ave 8th Fl		New York	NY	10172	212-270-0426	212-270-0430	gianni.russello@jpmorgan.com susan.atkins@jpmorgan.com	Postpetition Administrative Agent
Kramer Levin Naftalis & Frankel LLP	Gordon Z. Novod	1177 Avenue of the Americas		New York	NY	10036	212-715-9100	212-715-8000	gnovod@kramerlevin.com	Counsel Data Systems Corporation; EDS Information Services, LLC
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Kurtzman Carson Consultants	Sheryl Betance	2335 Alaska Ave		El Segundo	CA	90245	310-823-9000	310-823-9133	sbetance@kccllc.com	Noticing and Claims Agent
Latham & Watkins LLP	Robert J. Rosenberg	885 Third Avenue		New York	NY	10022	212-906-1370	212-751-4864	robert.rosenberg@lw.com	Counsel to Official Committee of Unsecured Creditors
Law Debenture Trust of New York	Daniel R. Fisher	400 Madison Ave	Fourth Floor	New York	NY	10017	212-750-6474	212-750-1361	daniel.fisher@lawdeb.com	Indenture Trustee
Law Debenture Trust of New York	Patrick J. Healy	400 Madison Ave	Fourth Floor	New York	NY	10017	212-750-6474	212-750-1361	patrick.healy@lawdeb.com	Indenture Trustee

COMPANY	CONTACT	ADDRESS1	ADDRESS2	CITY	STATE	ZIP	PHONE	FAX	EMAIL	PARTY / FUNCTION
McDermott Will & Emery LLP	David D. Cleary	227 West Monroe Street	Suite 5400	Chicago	IL	60606	312-372-2000	312-984-7700	dcleary@mwe.com	Counsel to Recticel North America, Inc.
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McDermott Will & Emery LLP	Peter A. Clark	227 West Monroe Street	Suite 5400	Chicago	IL	60606	312-372-2000	312-984-7700	pclark@mwe.com	Counsel to Recticel North America, Inc.
McTigue Law Firm	Cornish F. Hitchcock	5301 Wisconsin Ave. N.W.	Suite 350	Washington	DC	20015	202-364-6900	202-364-9960	conh@mctiguelaw.com	Counsel to Movant Retirees and Proposed Counsel to The Official Committee of Retirees
McTigue Law Firm	J. Brian McTigue	5301 Wisconsin Ave. N.W.	Suite 350	Washington	DC	20015	202-364-6900	202-364-9960	bmctigue@mctiguelaw.com	Counsel to Movant Retirees and Proposed Counsel to The Official Committee of Retirees
Mesirow Financial	Leon Szlezinger	666 Third Ave	21st Floor	New York	NY	10017	212-808-8366	212-682-5015	lszlezinger@mesirowfinancial.com	UCC Professional
Milbank Tweed Hadley & McCloy LLP	Gregory A Bray Esq Thomas R Kreller Esq James E Till Esq	601 South Figueroa Street	30th Floor	Los Angeles	CA	90017	213-892-4000	213-629-5063	gbray@milbank.com tkreller@milbank.com jtill@milbank.com	Counsel to Cerberus Capital Management LP and Dolce Investments LLC
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Office of New York State	Attorney General Eliot Spitzer	120 Broadway		New York City	NY	10271	212-416-8000	212-416-6075	ServeAG@oag.state.ny.us	New York Attorney General's Office
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Skadden, Arps, Slate, Meagher & Flom LLP	John Wm. Butler, John K. Lyons, Ron E. Meisler	333 W. Wacker Dr.	Suite 2100	Chicago	IL	60606	312-407-0700	312-407-0411	jbutler@skadden.com jlyonsch@skadden.com rmeisler@skadden.com	Counsel to the Debtor
Skadden, Arps, Slate, Meagher & Flom LLP	Kayalyn A. Marafioti, Thomas J. Matz	4 Times Square	P.O. Box 300	New York	NY	10036	212-735-3000	212-735-2000	kmarafio@skadden.com tmatz@skadden.com	Counsel to the Debtor
Spencer Fane Britt & Browne LLP	Daniel D. Doyle	1 North Brentwood Boulevard	Tenth Floor	St. Louis	MO	63105	314-863-7733	314-862-4656	ddoyle@spencerfane.com	Counsel to Movant Retirees and Proposed Counsel to The Official Committee of Retirees
Spencer Fane Britt & Browne LLP	Nicholas Franke	1 North Brentwood Boulevard	Tenth Floor	St. Louis	MO	63105	314-863-7733	314-862-4656	nfranke@spencerfane.com	Counsel to Movant Retirees and Proposed Counsel to The Official Committee of Retirees
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Togut, Segal & Segal LLP	Albert Togut	One Penn Plaza	Suite 3335	New York	NY	10119	212-594-5000	212-967-4258	altogut@teamtogut.com	Conflicts Counsel to the Debtors
Tyco Electronics Corporation	MaryAnn Brereton, Assistant General Counsel	60 Columbia Road		Morristown	NJ	7960	973-656-8365	973-656-8805		Creditor Committee Member

Delphi Corporation
Master Service List

COMPANY	CONTACT	ADDRESS1	ADDRESS2	CITY	STATE	ZIP	PHONE	FAX	EMAIL	PARTY / FUNCTION
United States Trustee	Alicia M. Leonhard	33 Whitehall Street	21st Floor	New York	NY	10004-2112	212-510-0500	212-668-2255 does not take service via fax		Counsel to United States Trustee
Warner Stevens, L.L.P.	Michael D. Warner	1700 City Center Tower II	301 Commerce Street	Fort Worth	TX	76102	817-810-5250	817-810-5255	mwarner@warnerstevens.com	Proposed Conflicts Counsel to the Official Committee of Unsecured Creditors
Weil, Gotshal & Manges LLP	Harvey R. Miller	767 Fifth Avenue		New York	NY	10153	212-310-8500	212-310-8077	harvey.miller@weil.com	Counsel to General Motors Corporation
Weil, Gotshal & Manges LLP	Jeffrey L. Tanenbaum, Esq.	767 Fifth Avenue		New York	NY	10153	212-310-8000	212-310-8007	jeff.tanenbaum@weil.com	Counsel to General Motors Corporation
Weil, Gotshal & Manges LLP	Martin J. Bienenstock, Esq.	767 Fifth Avenue		New York	NY	10153	212-310-8000	212-310-8007	martin.bienenstock@weil.com	Counsel to General Motors Corporation
Weil, Gotshal & Manges LLP	Michael P. Kessler, Esq.	767 Fifth Avenue		New York	NY	10153	212-310-8000	212-310-8007	michael.kessler@weil.com	Counsel to General Motors Corporation
Wilmington Trust Company	Steven M. Cimalore	Rodney Square North	1100 North Market Street	Wilmington	DE	19890	302-636-6058	302-636-4143	scimalore@wilmingtontrust.com	Creditor Committee Member/Indenture Trustee

EXHIBIT B

Delphi Corporation
Master Service List

COMPANY	CONTACT	ADDRESS1	ADDRESS2	CITY	STATE	ZIP	PHONE	FAX	EMAIL	PARTY / FUNCTION
Brown Rudnick Berlack Israels LLP	Robert J. Stark	Seven Times Square		New York	NY	10036	212-209-4800	212-2094801	rstark@brownrudnick.com	Indenture Trustee
Cohen, Weiss & Simon	Bruce Simon	330 W. 42nd Street		New York	NY	10036	212-356-0231	212-695-5436	bsimon@cwsny.com	
Curtis, Mallet-Prevost, Colt & mosle LLP	Steven J. Reisman	101 Park Avenue		New York	NY	10178-0061	2126966000	2126971559	sreisman@cm-p.com	Counsel to Flextronics International, Inc., Flextronics International USA, Inc.; Multek Flexible Circuits, Inc.; Sheldahl de Mexico S.A.de C.V.; Northfield Acquisition Co.; Flextronics Asia-Pacific Ltd.; Flextronics Technology (M) Sdn. Bhd
Davis, Polk & Wardwell	Donald Bernstein Brian Resnick	450 Lexington Avenue		New York	NY	10017	212-450-4092 212-450-4213	212-450-3092 212-450-3213	donald.bernstein@dpw.com brian.resnick@dpw.com	Counsel to Debtor's Postpetition Administrative Agent
Delphi Corporation	Sean Corcoran, Karen Craft	5725 Delphi Drive		Troy	MI	48098	248-813-2000	248-813-2491	sean.p.corcoran@delphi.com karen.j.craft@delphi.com	Debtors
Electronic Data Systems Corp.	Michael Nefkens	5505 Corporate Drive MSIA		Troy	MI	48098	248-696-1729	248-696-1739	mike.nefkens@eds.com	Creditor Committee Member
Flextronics International	Carrie L. Schiff	305 Interlocken Parkway		Broomfield	CO	80021	303-927-4853	303-652-4716	cschiff@flextronics.com	Counsel to Flextronics International
Flextronics International USA, Inc.	Paul W. Anderson	2090 Fortune Drive		San Jose	CA	95131	408-428-1308		paul.anderson@flextronics.com	Counsel to Flextronics International USA, Inc.
Freescale Semiconductor, Inc.	Richard Lee Chambers, III	6501 William Cannon Drive West	MD: OE16	Austin	TX	78735	512-895-6357	512-895-3090	trey.chambers@freescale.com	Creditor Committee Member
Fried, Frank, Harris, Shriver & Jacobson	Brad Eric Sheler Bonnie Steingart Vivek Melwani Jennifer L Rodburg Richard J Slivinski	One New York Plaza		New York	NY	10004	212-859-8000	212-859-4000	rodbuje@ffhsj.com sliviri@ffhsj.com	Counsel to Equity Security Holders Committee
FTI Consulting, Inc.	Randall S. Eisenberg	3 Times Square	11th Floor	New York	NY	10036	212-2471010	212-841-9350	randall.eisenberg@fticonsulting.com	Financial Advisors to Debtors
General Electric Company	Valerie Venable	9930 Kincey Avenue		Huntersville	NC	28078	704-992-5075	866-585-2386	valerie.venable@ge.com	Creditor Committee Member
Groom Law Group	Lonie A. Hassel	1701 Pennsylvania Avenue, NW		Washington	DC	20006	202-857-0620	202-659-4503	lhassel@groom.com	Counsel to Employee Benefits
Hodgson Russ LLP	Stephen H. Gross	1540 Broadway	24th Fl	New York	NY	10036	212-751-4300	212-751-0928	sgross@hodgsonruss.com	Counsel to Hexcel Corporation
Honigman Miller Schwartz and Cohn LLP	Frank L. Gorman, Esq.	2290 First National Building	660 Woodward Avenue	Detroit	MI	48226-3583	313-465-7000	313-465-8000	fgorman@honigman.com	Counsel to General Motors Corporation
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Jefferies & Company, Inc,	William Q. Derrough	520 Madison Avenue	12th Floor	New York	NY	10022	212-284-2521	212-284-2470	bderrough@jefferies.com	UCC Professional
JPMorgan Chase Bank, N.A.	Richard Duker	270 Park Avenue		New York	NY	10017	212-270-5484	212-270-4016	richard.duker@jpmorgan.com	Prepetition Administrative Agent
JPMorgan Chase Bank, N.A.	Susan Atkins, Gianni Russello	277 Park Ave 8th Fl		New York	NY	10172	212-270-0426	212-270-0430	gianni.russello@jpmorgan.com	Postpetition Administrative Agent
Kramer Levin Naftalis & Frankel LLP	Gordon Z. Novod	1177 Avenue of the Americas		New York	NY	10036	212-715-9100	212-715-8000	gnovod@kramerlevin.com	Counsel Data Systems Corporation; EDS Information Services, LLC
Kramer Levin Naftalis & Frankel LLP	Thomas Moers Mayer	1177 Avenue of the Americas		New York	NY	10036	212-715-9100	212-715-8000	tmayer@kramerlevin.com	Counsel Data Systems Corporation; EDS Information Services, LLC
Kurtzman Carson Consultants	Sheryl Betance	2335 Alaska Ave		El Segundo	CA	90245	310-823-9000	310-823-9133	sbetance@kccllc.com	Noticing and Claims Agent
Latham & Watkins LLP	Robert J. Rosenberg	885 Third Avenue		New York	NY	10022	212-906-1370	212-751-4864	robert.rosenberg@lw.com	Counsel to Official Committee of Unsecured Creditors
Law Debenture Trust of New York	Daniel R. Fisher	400 Madison Ave	Fourth Floor	New York	NY	10017	212-750-6474	212-750-1361	daniel.fisher@lawdeb.com	Indenture Trustee
Law Debenture Trust of New York	Patrick J. Healy	400 Madison Ave	Fourth Floor	New York	NY	10017	212-750-6474	212-750-1361	patrick.healy@lawdeb.com	Indenture Trustee
McDermott Will & Emery LLP	Jason J. DeJonker	227 West Monroe Street	Suite 5400	Chicago	IL	60606	312-372-2000	312-984-7700	jdejonker@mwe.com	Counsel to Recticel North America, Inc.

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McDermott Will & Emery LLP	Peter A. Clark	227 West Monroe Street	Suite 5400	Chicago	IL	60606	312-372-2000	312-984-7700	pclark@mwe.com	Counsel to Recticel North America, Inc.
McTigue Law Firm	Cornish F. Hitchcock	5301 Wisconsin Ave. N.W.	Suite 350	Washington	DC	20015	202-364-6900	202-364-9960	conh@mctiguelaw.com	Counsel to Movant Retirees and Proposed Counsel to The Official Committee of Retirees
McTigue Law Firm	J. Brian McTigue	5301 Wisconsin Ave. N.W.	Suite 350	Washington	DC	20015	202-364-6900	202-364-9960	bmctigue@mctiguelaw.com	Counsel to Movant Retirees and Proposed Counsel to The Official Committee of Retirees
Mesirow Financial	Leon Szlezinger	666 Third Ave	21st Floor	New York	NY	10017	212-808-8366	212-682-5015	lszlezinger@mesirowfinancial.com	UCC Professional
Milbank Tweed Hadley & McCloy LLP	Gregory A Bray Esq Thomas R Kreller Esq James E Till Esq	601 South Figueroa Street	30th Floor	Los Angeles	CA	90017	213-892-4000	213-629-5063	gbray@milbank.com tkreller@milbank.com jtill@milbank.com	Counsel to Cerberus Capital Management LP and Dolce Investments LLC
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EXHIBIT C

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Airgas, Inc.	David Boyle	259 Radnor-Chester Road, Suite 100	P.O. Box 6675	Radnor	PA	19087-8675	610-230-3064	Counsel to Airgas, Inc.
Akebono Corporation (North America)	Alan Swiech	34385 Twelve Mile Road		Farminton Hills	MI	48331	248-489-7406	Vice President of Administration for Akebono Corporation
APS Clearing, Inc.	Andy Leinhoff Matthew Hamilton	1301 S. Capital of Texas Highway	Suite B-220	Austin	TX	78746	512-314-4416	Counsel to APS Clearing, Inc.
Berry Moorman P.C.	James P. Murphy	535 Griswold	Suite 1900	Detroit	MI	48226	313-496-1200	Counsel to Kamax L.P.; Optrex America, Inc.
Bingham McHale LLP	Michael J Alerding	10 West Market Street	Suite 2700	Indianapolis	IN	46204	317-635-8900	Counsel to Universal Tool & Engineering co., Inc. and M.G. Corporation
Cage Williams & Abelman, P.C.	Steven E. Abelman	1433 Seventeenth Street		Denver	CO	80202	303-295-0202	Counsel to United Power, Inc.
Colbert & Winstead, P.C.	Amy Wood Malone	1812 Broadway		Nashville	TN	37203	615-321-0555	Counsel to Averitt Express, Inc.
Coolidge, Wall, Womsley & Lombard Co. LPA	Steven M. Wachstein	33 West First Street	Suite 600	Dayton	OH	45402	937-223-8177	Counsel to Harco Industries, Inc.; Harco Brake Systems, Inc.; Dayton Supply & Tool Coompany
Curtis, Mallet-Prevost, Colt & Mosle LLP	Andrew M. Thau	101 Park Avenue		New York	NY	10178-0061	212-696-8898	Counsel to Flextronics International, Inc., Flextronics International USA, Inc.; Multek Flexible Circuits, Inc.; Sheldahl de Mexico S.A.de C.V.; Northfield Acquisition Co.; Flextronics Asia-Pacific Ltd.; Flextronics Technology (M) Sdn. Bhd
Curtis, Mallet-Prevost, Colt & Mosle LLP	David S. Karp	101 Park Avenue		New York	NY	10178-0061	212-696-6065	Counsel to Flextronics International, Inc., Flextronics International USA, Inc.; Multek Flexible Circuits, Inc.; Sheldahl de Mexico S.A.de C.V.; Northfield Acquisition Co.
DaimlerChrysler Corporation	Kim Kolb	CIMS 485-13-32	1000 Chrysler Drive	Auburn Hills	MI	48326-2766	248-576-5741	Counsel to DaimlerChrysler Corporation; DaimlerChrylser Motors Company, LLC; DaimlerChrylser Canada, Inc.
DiConza Law, P.C.	Gerard DiConza, Esq.	630 Third Avenue, 7th Floor		New York	NY	10017	212-682-4940	Counsel to Tyz-All Plastics, Inc.; Furukawa Electric North America APD; and Co-Counsel to Tower Automotive, Inc.
Dykema Gossett PLLC	Gregory J. Jordan	10 Wacker	Suite 2300	Chicago	IL	60606	312-627-2171	Counsel to Tremont City Barrel Fill PRP Group
Fagel Haber LLC	Gary E. Green	55 East Monroe	40th Floor	Chicago	IL	60603	312-346-7500	Counsel to Aluminum International, Inc.
Genovese Joblove & Battista, P.A.	Craig P. Rieders, Esq.	100 S.E. 2nd Street	Suite 4400	Miami	FL	33131	305-349-2300	Counsel to Ryder Integrated Logistics, Inc.
Grant & Eisenhofer P.A.	Geoffrey C. Jarvis	1201 North Market Street	Suite 2100	Wilmington	DE	19801	302-622-7000	Counsel to Teachers Retirement System of Oklahoma; Public Employes's Retirement System of Mississippi; Raifeisen Kapitalanlage-Gesellschaft m.b.H and Stichting Pensioenfords ABP

Delphi Corporation
2002 List

COMPANY	CONTACT	ADDRESS1	ADDRESS2	CITY	STATE	ZIP	PHONE	PARTY / FUNCTION
Heller Ehrman LLP	Carren Shulman	Times Square Tower	Seven Times Square	New York	NY	10036	212-832-8300	Counsel to @Road, Inc.
Hunter & Schank Co. LPA	John J. Hunter	One Canton Square	1700 Canton Avenue	Toledo	OH	43624	419-255-4300	Counsel to ZF Group North America Operations, Inc.
Hunter & Schank Co. LPA	Thomas J. Schank	One Canton Square	1700 Canton Avenue	Toledo	OH	43624	419-255-4300	Counsel to ZF Group North America Operations, Inc.
Jason, Inc.	Beth Klimczak, General Counsel	411 E. Wisconsin Ave	Suite 2120	Milwaukee	WI	53202		General Counsel to Jason Incorporated
Johnston, Harris Gerde & Komarek, P.A.	Jerry W. Gerde, Esq.	239 E. 4th St.		Panama City	FL	32401	850-763-8421	Counsel to Peggy C. Brannon, Bay County Tax Collector
Kelley Drye & Warren, LLP	Mark I. Bane	101 Park Avenue		New York	NY	10178	212-808-7800	Counsel to the Pension Benefit Guaranty Corporation
Kelley Drye & Warren, LLP	Mark. R. Somerstein	101 Park Avenue		New York	NY	10178	212-808-7800	Counsel to the Pension Benefit Guaranty Corporation
Lord, Bissel & Brook LLP	Rocco N. Covino	885 Third Avenue	26th Floor	New York	NY	10022-4802	212-812-8340	Counsel to Sedgwick Claims Management Services, Inc. and Methode Electronics, Inc.
McGuirewoods LLP	Elizabeth L. Gunn	One James Center	901 East Cary Street	Richmond	VA	23219-4030	804-775-1178	Counsel to Siemens Logistics Assembly Systems, Inc.
Miami-Dade County Tax Collector	Metro-Dade Paralegal Unit	140 West Flagler Street	Suite 1403	Miami	FL	33130	305-375-5314	Paralegal Collection Specialist for Miami-Dade County
Norris, McLaughlin & Marcus	Elizabeth L. Abdelmasieh, Esq	721 Route 202-206	P.O. Box 1018	Somerville	NJ	08876	908-722-0700	Counsel to Rotor Clip Company, Inc.
North Point	Michelle M. Harner	901 Lakeside Avenue		Cleveland	OH	44114	216-586-3939	Counsel to WL. Ross & Co., LLC
O'Rourke Katten & Moody	Michael C. Moody	161 N. Clark Street	Suite 2230	Chicago	IL	60601	312-849-2020	Counsel to Ameritech Credit Corporation d/b/a SBC Capital Services
Orrick, Herrington & Sutcliffe LLP	Matthew W. Cheney	The Washington Harbour	3050 K Street, N.W.	Washington	DC	20007	202-339-8400	Counsel to Westwood Associates, Inc.
Paul, Weiss, Rifkind, Wharton & Garrison	Curtis J. Weidler	1285 Avenue of the Americas		New York	NY	10019-6064	212-373-3157	Counsel to Ambrake Corporation; Akebono Corporation
Professional Technologies Services	John V. Gorman	P.O. Box #304		Frankenmuth	MI	48734	989-385-3230	Corporate Secretary for Professional Technologies Services
Republic Engineered Products, Inc.	Joseph Lapinsky	3770 Embassy Parkway		Akron	OH	44333	330-670-3004	Counsel to Republic Engineered Products, Inc.
Ropers, Majeski, Kohn & Bentley	Christopher Norgaard	515 South Flower Street	Suite 1100	Los Angeles	CA	90071	213-312-2000	Counsel to Brembo S.p.A; Bibielle S.p.A.; AP Racing
Sachnoff & Weaver, Ltd	Charles S. Schulman	10 South Wacker Drive	40th Floor	Chicago	IL	60606	312-207-1000	Counsel to Infineon Technologies North America Corporation
Schafer and Weiner PLLC	Max Newman	40950 Woodward Ave.	Suite 100	Bloomfield Hills	MI	48304	248-540-3340	Counsel to Dott Industries, Inc.
Schiff Hardin LLP	William I. Kohn	6600 Sears Tower		Chicago	IL	60066	312-258-5500	Counsel to Means Industries
Shipman & Goodwin LLP	Jennifer L. Adamy	One Constitution Plaza		Hartford	CT	06103-1919	860-251-5811	Counsel to Fortune Plastics Company of Illinois, Inc.; Universal Metal Hose Co.,

Delphi Corporation
2002 List

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Stroock & Stroock & Lavan, LLP	Joseph G. Minias	180 Maiden Lane		New York	NY	10038	212-806-5400	Counsel to 975 Opdyke LP; 1401 Troy Associates Limited Partnership; 1401 Troy Associates Limited Partnership c/o Etkin Equities, Inc.; 1401 Troy Associates LP; Brighton Limited Partnership; DPS Information Services, Inc.; Etkin Management Services, Inc. a
Swidler Berlin LLP	Robert N. Steinwurtzel	The Washington Harbour	3000 K Street, N.W. Suite 300	Washington	DC	20007	202-424-7500	Attorneys for Sanders Lead Co., Inc.
Togut, Segal & Segal LLP	Albert Togut, Esq.	One Penn Plaza	Suite 3335	New York	NY	10119	212-594-5000	Conflicts counsel to Debtors
United Steel, Paper and Forestry, Rubber, Manufacturing, Energy	Allied Industrial and Service Workers, Intl Union (USW), AFL-CIO	David Jury, Esq.	Five Gateway Center Suite 807	Pittsburgh	PA	15222	412-562-2549	Counsel to United Steel, Paper and Forestry, Rubber, Manufacturing, Energy, Allied Industrial and Service Workers, International Union (USW), AFL-CIO
Vorys, Sater, Seymour and Pease LLP	Robert J. Sidman, Esq.	52 East Gay Street	P.O. Box 1008	Columbus	OH	43216-1008	614-464-6422	
Vorys, Sater, Seymour and Pease LLP	Tiffany Strelow Cobb	52 East Gay Street		Columbus	OH	43215	614-464-8322	Counsel to America Online, Inc. and its Subsidiaries and Affiliates
Warner Stevens, L.L.P.	Michael D. Warner	301 Commerce Street	Suite 1700	Fort Worth	TX	76102	817-810-5250	Counsel to Electronic Data Systems Corp. and EDS Information Services, L.L.C.
Winstead Sechrest & Minick P.C.	Berry D. Spears	401 Congress Avenue	Suite 2100	Austin	TX	78701	512-370-2800	Counsel to National Instruments Corporation
WL Ross & Co., LLC	Stephen Toy	600 Lexington Avenue	19th Floor	New York	NY	10022	212-826-1100	Counsel to WL. Ross & Co., LLC

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Delphi Legal Information Website:
http://www.delphidocket.com

UNITED STATES BANKRUPTCY COURT
SOUTHERN DISTRICT OF NEW YORK

- -	x	
	:	
In re	:	Chapter 11
	:	
DELPHI CORPORATION, et al.,	:	Case No. 05-44481 (RDD)
	:	
Debtors.	:	(Jointly Administered)
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NOTICE OF PRESENTMENT OF JOINT STIPULATION AND AGREED ORDER COMPROMISING AND ALLOWING PROOF OF CLAIM NUMBER 8914 (KLASH, INC.)

PLEASE TAKE NOTICE that on February 15, 2007, Delphi Corporation and certain of its subsidiaries and affiliates, debtors and debtors-in-possession in the above-captioned cases (collectively, the "Debtors"), objected to proof of claim number 8914 (the "Proof of Claim") filed by Klash, Inc. (the "Claimant") pursuant to the Debtors' Ninth Omnibus Objection (Substantive) Pursuant To 11 U.S.C. § 502(b) And Fed. R. Bankr. P. 3007 To Certain (a) Insufficiently Documented Claims, (b) Claims Not Reflected On Debtors' Books And Records, (c) Untimely Claims, And (d) Claims Subject To Modification (Docket No. 6968) (the "Ninth Omnibus Claims Objection").

PLEASE TAKE FURTHER NOTICE that the Debtors and the Claimant have agreed to settle the Ninth Omnibus Claims Objection with respect to the Proof of Claim, and because the claim (the "Claim") asserted in the Proof of Claim involves an ordinary course controversy and pursuant to the Amended And Restated Order Under 11 U.S.C. §§ 363, 502 And 503 And Fed. R. Bankr. P. 9019(b) Authorizing Debtors To Compromise Or Settle Certain Classes Of Controversy And Allow Claims Without Further Court Approval (Docket No. 8401), the Debtors and the Claimant have (i) entered into a Settlement Agreement dated as of July 13, 2007 (the "Settlement Agreement") and (ii) executed a Joint Stipulation And Agreed Order Compromising And Allowing Proof Of Claim Number 8914 (Klash, Inc.) (the "Joint Stipulation").

PLEASE TAKE FURTHER NOTICE that, pursuant to the Settlement Agreement and the Joint Stipulation, the Debtors and the Claimant have agreed to allow the Claim as a general unsecured non-priority claim in the amount of $15,246.00 and the Claimant shall withdraw its response (Docket No. 7321) to the Ninth Omnibus Claims Objection with prejudice.

PLEASE TAKE FURTHER NOTICE that the Debtors will present the Joint Stipulation for consideration at the hearing scheduled for July 20, 2007 at 10:00 a.m. (prevailing Eastern time) in the United States Bankruptcy Court for the Southern District of New York.

Dated: New York, New York
July 13, 2007

SKADDEN, ARPS, SLATE, MEAGHER & FLOM LLP

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UNITED STATES BANKRUPTCY COURT
SOUTHERN DISTRICT OF NEW YORK

- -	x	
	:	
In re	:	Chapter 11
	:	
DELPHI CORPORATION, et al.,	:	Case No. 05-44481 (RDD)
	:	
Debtors.	:	(Jointly Administered)
	:	
- -	x	

NOTICE OF PRESENTMENT OF JOINT STIPULATION AND AGREED ORDER
COMPROMISING AND ALLOWING PROOF OF CLAIM NUMBER 2440
(SIERRA LIQUIDITY FUND, LLC AS ASSIGNEE OF APPLIED TECH INDUSTRIES, INC.)

PLEASE TAKE NOTICE that on February 15, 2007, Delphi Corporation and certain of its subsidiaries and affiliates, debtors and debtors-in-possession in the above-captioned cases (collectively, the "Debtors"), objected to proof of claim number 2440 (the "Proof of Claim") filed by Sierra Liquidity Fund, LLC as assignee of Applied Tech Industries, Inc. (the "Claimant") pursuant to the Debtors' Ninth Omnibus Objection (Substantive) Pursuant To 11 U.S.C. § 502(b) And Fed. R. Bankr. P. 3007 To Certain (a) Insufficiently Documented Claims, (b) Claims Not Reflected On Debtors' Books And Records, (c) Untimely Claims, And (d) Claims Subject To Modification (Docket No. 6968) (the "Ninth Omnibus Claims Objection").

PLEASE TAKE FURTHER NOTICE that the Debtors and the Claimant have agreed to settle the Ninth Omnibus Claims Objection with respect to the Proof of Claim, and because the claim (the "Claim") asserted in the Proof of Claim involves an ordinary course controversy and pursuant to the Amended And Restated Order Under 11 U.S.C. §§ 363, 502 And 503 And Fed. R. Bankr. P. 9019(b) Authorizing Debtors To Compromise Or Settle Certain Classes Of Controversy And Allow Claims Without Further Court Approval (Docket No. 8401), the Debtors and the Claimant have (i) entered into a Settlement Agreement dated as of July 13, 2007 (the "Settlement Agreement") and (ii) executed a Joint Stipulation And Agreed Order Compromising And Allowing Proof Of Claim Number 2440 (Sierra Liquidity Fund, LLC As Assignee Of Applied Tech Industries, Inc.) (the "Joint Stipulation").

PLEASE TAKE FURTHER NOTICE that, pursuant to the Settlement Agreement and the Joint Stipulation, the Debtors and the Claimant have agreed to allow the Claim as a general unsecured non-priority claim in the amount of $3,690.68 and the Claimant shall withdraw its Response To Ninth Omnibus Objection To Claims By Delphi Corporation, Et Al;

Sierra Liquidity Fund, LLC (Assignee); Applied Tech Industries, Inc. (Assignor), Claim No. 2440 (Docket No. 7233) with prejudice.

PLEASE TAKE FURTHER NOTICE that the Debtors will present the Joint Stipulation for consideration at the hearing scheduled for July 20, 2007 at 10:00 a.m. (prevailing Eastern time) in the United States Bankruptcy Court for the Southern District of New York.

Dated: New York, New York
July 13, 2007

SKADDEN, ARPS, SLATE, MEAGHER &
FLOM LLP

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UNITED STATES BANKRUPTCY COURT
SOUTHERN DISTRICT OF NEW YORK

In re	:	Chapter 11
DELPHI CORPORATION, et al.,	:	Case No. 05-44481 (RDD)
Debtors.	:	(Jointly Administered)

NOTICE OF PRESENTMENT OF JOINT STIPULATION AND AGREED ORDER
COMPROMISING AND ALLOWING PROOF OF CLAIM NUMBER 14663
(SIERRA LIQUIDITY FUND, LLC, AS ASSIGNEE
OF FAIR-RITE PRODUCTS CORPORATION)

PLEASE TAKE NOTICE that on February 15, 2007, Delphi Corporation and certain of its subsidiaries and affiliates, debtors and debtors-in-possession in the above-captioned cases (collectively, the "Debtors"), objected to proof of claim number 14663 (the "Proof of Claim") filed by Sierra Liquidity Fund, LLC as assignee of Fair-Rite Products Corporation (the "Claimant") pursuant to the Debtors' Ninth Omnibus Objection (Substantive) Pursuant To 11 U.S.C. § 502(b) And Fed. R. Bankr. P. 3007 To Certain (a) Insufficiently Documented Claims, (b) Claims Not Reflected On Debtors' Books And Records, (c) Untimely Claims, And (d) Claims Subject To Modification (Docket No. 6968) (the "Ninth Omnibus Claims Objection").

PLEASE TAKE FURTHER NOTICE that the Debtors and the Claimant have agreed to settle the Ninth Omnibus Claims Objection with respect to the Proof of Claim, and because the claim (the "Claim") asserted in the Proof of Claim involves an ordinary course controversy and pursuant to the Amended And Restated Order Under 11 U.S.C. §§ 363, 502 And 503 And Fed. R. Bankr. P. 9019(b) Authorizing Debtors To Compromise Or Settle Certain Classes Of Controversy And Allow Claims Without Further Court Approval (Docket No. 8401), the Debtors and the Claimant have (i) entered into a Settlement Agreement dated as of July 13, 2007 (the "Settlement Agreement") and (ii) executed a Joint Stipulation And Agreed Order Compromising And Allowing Proof Of Claim Number 14663 (Sierra Liquidity Fund, LLC, As Assignee Of Fair-Rite Products Corporation) (the "Joint Stipulation").

PLEASE TAKE FURTHER NOTICE that, pursuant to the Settlement Agreement and the Joint Stipulation, the Debtors and the Claimant have agreed to allow the Claim as a general unsecured non-priority claim in the amount of $16,262.96 and the Claimant shall withdraw its Response To Ninth Omnibus Objection To Claims By Delphi Corporation, Et Al;

Sierra Liquidity Fund, LLC (Assignee); Fair-Rite Products Corporation (Assignor), Claim No. 14663 (Docket No. 7237) with prejudice.

PLEASE TAKE FURTHER NOTICE that the Debtors will present the Joint Stipulation for consideration at the hearing scheduled for July 20, 2007 at 10:00 a.m. (prevailing Eastern time) in the United States Bankruptcy Court for the Southern District of New York.

Dated: New York, New York
July 13, 2007

SKADDEN, ARPS, SLATE, MEAGHER &
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UNITED STATES BANKRUPTCY COURT
SOUTHERN DISTRICT OF NEW YORK

- x		
In re	:	Chapter 11
DELPHI CORPORATION, et al.,	:	Case No. 05-44481 (RDD)
Debtors.	:	(Jointly Administered)
- x		

NOTICE OF PRESENTMENT OF JOINT STIPULATION AND AGREED ORDER COMPROMISING AND ALLOWING PROOF OF CLAIM NUMBER 9402 (BONA VISTA PROGRAMS, INC.)

PLEASE TAKE NOTICE that on March 16, 2007, Delphi Corporation and certain of its subsidiaries and affiliates, debtors and debtors-in-possession in the above-captioned cases (collectively, the "Debtors"), objected to proof of claim number 9402 (the "Proof of Claim") filed by Bona Vista Programs, Inc. (the "Claimant") pursuant to the Debtors' Eleventh Omnibus Objection (Substantive) Pursuant To 11 U.S.C. § 502(b) And Fed. R. Bankr. P. 3007 To Certain (a) Insufficiently Documented Claims, (b) Claims Not Reflected On Debtors' Books And Records, (c) Untimely Claims, And (d) Claims Subject To Modification (Docket No. 7301) (the "Eleventh Omnibus Claims Objection").

PLEASE TAKE FURTHER NOTICE that the Debtors and the Claimant have agreed to settle the Eleventh Omnibus Claims Objection with respect to the Proof of Claim, and because the claim (the "Claim") asserted in the Proof of Claim involves an ordinary course controversy and pursuant to the Amended And Restated Order Under 11 U.S.C. §§ 363, 502 And 503 And Fed. R. Bankr. P. 9019(b) Authorizing Debtors To Compromise Or Settle Certain Classes Of Controversy And Allow Claims Without Further Court Approval (Docket No. 8401), the Debtors and the Claimant have (i) entered into a Settlement Agreement dated as of July 13, 2007 (the "Settlement Agreement") and (ii) executed a Joint Stipulation And Agreed Order Compromising And Allowing Proof Of Claim Number 9402 (Bona Vista Programs, Inc.) (the "Joint Stipulation").

PLEASE TAKE FURTHER NOTICE that, pursuant to the Settlement Agreement and the Joint Stipulation, the Debtors and the Claimant have agreed to allow the Claim as a general unsecured non-priority claim in the amount of $15,383.14 and the Claimant shall withdraw its letter response (Docket No. 7650) to the Eleventh Omnibus Claims Objection with prejudice.

PLEASE TAKE FURTHER NOTICE that the Debtors will present the Joint Stipulation for consideration at the hearing scheduled for July 20, 2007 at 10:00 a.m. (prevailing Eastern time) in the United States Bankruptcy Court for the Southern District of New York.

Dated: New York, New York
July 13, 2007

SKADDEN, ARPS, SLATE, MEAGHER &
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Delphi Legal Information Website:
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UNITED STATES BANKRUPTCY COURT
SOUTHERN DISTRICT OF NEW YORK

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	:	
In re	:	Chapter 11
	:	
DELPHI CORPORATION, et al.,	:	Case No. 05-44481 (RDD)
	:	
Debtors.	:	(Jointly Administered)
	:	
- -	x	

NOTICE OF FURTHER ADJOURNMENT OF CLAIMS OBJECTION HEARING WITH RESPECT TO DEBTORS' OBJECTION TO PROOFS OF CLAIM NOS. 837 AND 838

(H.E. SERVICES COMPANY AND ROBERT BACKIE)

PLEASE TAKE NOTICE that on October 31, 2006, Delphi Corporation and certain of its subsidiaries and affiliates, debtors and debtors-in-possession in the above-captioned cases (collectively, the "Debtors"), objected to proofs of claim numbers 2237 and 2238[1] (the "Proofs of Claim") filed by Robert Backie and H.E. Services (the "Claimants") pursuant to the Debtors' (i) Third Omnibus Objection (Substantive) Pursuant To 11 U.S.C. § 502(b) And Fed. R. Bankr. P. 3007 To Certain (a) Claims With Insufficient Documentation, (b) Claims Unsubstantiated By Debtors' Books And Records, And (c) Claims Subject To Modification And (ii) Motion To Estimate Contingent And Unliquidated Claims Pursuant To 11 U.S.C. § 502(c) (Docket No. 5452) (the "Objection").

PLEASE TAKE FURTHER NOTICE that on December 11, 2006, the Debtors filed the Notices Of Claims Objection Hearing With Respect To Debtors' Objection To Proofs Of Claim Nos. 2237 and 2238 (Docket Nos. 6128 and, 6127) scheduling a claims objection hearing (the "Claims Objection Hearing") for purposes of holding an evidentiary hearing on the merits of the Proofs of Claim for February 14, 2007, at 10:00 a.m. (prevailing Eastern time). On February 2, 2007, the Debtors filed the Notice Of Adjournment Of Claims Objection Hearing With Respect To Debtors' Objection To Proof of Claim Nos. 2237, 2238 and 14762 (Robert Backie, H.E. Services Company, and Richard Janes) (Docket No. 6822) setting the Claims Objection Hearing for April 27, 2007. On April 20, 2007, the Debtors filed the Notice Of Adjournment Of Claims Objection Hearing With Respect to Debtors' Objection To Proofs Of

[1] By agreement of the parties, after the original Notices of Claims Objection Hearing were filed, proofs of claim numbers 2237 and 2238 were expunged as duplicate claims pursuant to the Order Pursuant To 11 U.S.C. Section 502(b) And Fed. R. Bankr. P. 3007 Disallowing And Expunging (I) Equity Claims, (II) Claims Duplicative Of Consolidated Trustee Or Agent Claims, And (III) Duplicate And Amended Claims Identified In Second Omnibus Claims Objection, entered December 21, 2006 (Docket No. 6255), leaving proofs of claim numbers 837 and 838 as the surviving claims.

Claim Nos. 837, 838, and 14762 (H.E. Services Company, Robert Backie, and Richard Janes[2]) (Docket No. 7767) setting the Claims Objection Hearing for June 22, 2007.

PLEASE TAKE FURTHER NOTICE that pursuant to Paragraph 9(a)(ii) of the Order Pursuant To 11 U.S.C. § 502(b) And Fed. R. Bankr. P. 2002(m), 3007, 7016, 7026, 9006, 9007, And 9014 Establishing (i) Dates For Hearings Regarding Objections To Claims And (ii) Certain Notices And Procedures Governing Objections To Claims, entered December 7, 2006 (Docket No. 6089) (the "Order"), and with the consent of the Claimants, the Claims Objection Hearing is hereby further adjourned to August 30, 2007, at 10:00 a.m. (prevailing Eastern time) in the United States Bankruptcy Court for the Southern District of New York (the "Court").

PLEASE TAKE FURTHER NOTICE that the Claims Objection Hearing will proceed in accordance with the procedures provided in the Order, unless such procedures are modified in accordance with Paragraph 9(k) thereof. All provisions and deadlines set forth in the Order shall remain in full force and effect. Those outstanding deadlines calculated based on the hearing date shall be calculated based on the August 30, 2007 hearing date rather than the original June 22, 2007 hearing date. Please review the Order carefully – failure to comply with the procedures provided in the Order (or as modified pursuant to Paragraph 9(k)) could result in the disallowance and expungement of the Proof of Claim. A copy of the Order is attached hereto for your convenience.

[2] Mr. Janes has since withdrawn his claim.

PLEASE TAKE FURTHER NOTICE that the Debtors may further adjourn the Claims Objection Hearing at any time at least five business days prior to the scheduled hearing upon notice to the Court and the Claimant.

Dated: New York, New York
July 13, 2007

SKADDEN, ARPS, SLATE, MEAGHER &
FLOM LLP

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Attorneys for Delphi Corporation, et al.,
Debtors and Debtors-in-Possession

UNITED STATES BANKRUPTCY COURT
SOUTHERN DISTRICT OF NEW YORK

In re	Chapter 11
DELPHI CORPORATION, et al.,	Case No. 05-44481 (RDD)
Debtors.	(Jointly Administered)

ORDER PURSUANT TO 11 U.S.C. § 502(b) AND FED. R. BANKR. P. 2002(m), 3007, 7016, 7026, 9006, 9007, AND 9014 ESTABLISHING (I) DATES FOR HEARINGS REGARDING OBJECTIONS TO CLAIMS AND (II) CERTAIN NOTICES AND PROCEDURES GOVERNING OBJECTIONS TO CLAIMS

("CLAIM OBJECTION PROCEDURES ORDER")

Upon the Motion For Order Pursuant To 11 U.S.C. §§ 502(b) And 502(c) And Fed. R. Bankr. P. 2002(m), 3007, 7016, 7026, 9006, 9007, And 9014 Establishing (i) Dates For Hearings Regarding Disallowance Or Estimation Of Claims And (ii) Certain Notices And Procedures Governing Hearings Regarding Disallowance Or Estimation Of Claims, dated October 31, 2006 (the "Motion"), of Delphi Corporation and certain of its subsidiaries and affiliates, debtors and debtors-in-possession in the above-captioned cases (collectively, the "Debtors"); and upon the objections to the Motion and the record of the hearing held on the Motion; and after due deliberation thereon; and good and sufficient cause appearing therefor,

IT IS HEREBY FOUND AND DETERMINED THAT:[1]

A. Proper, timely, adequate, and sufficient notice of the Motion has been provided, such notice was good, sufficient and appropriate under the particular circumstances, and no other or further notice of the Motion is or shall be required.

B. The Court has jurisdiction over the Motion pursuant to 28 U.S.C. §§ 157 and 1334. The Motion is a core proceeding under 28 U.S.C. § 157 (b)(2). Venue of these cases and the Motion in this district is proper under 28 U.S.C. §§ 1408 and 1409.

C. The relief requested in the Motion and granted herein is in the best interests of the Debtors, their estates, their creditors, and other parties-in-interest.

NOW THEREFORE, IT IS HEREBY ORDERED, ADJUDGED, AND DECREED THAT:

1. This Court shall conduct special periodic hearings on contested claims matters in these cases (the "Claims Hearing Dates"), to be held in Courtroom 610, United States Bankruptcy Court, Alexander Hamilton Custom House, One Bowling Green, New York, New York 10004 unless the Debtors and the parties whose claims are affected are otherwise notified by the Court. The following dates and times have been scheduled as Claims Hearing Dates in these chapter 11 cases:

December 13, 2006 at 10:00 a.m. (prevailing Eastern time)

January 12, 2007 at 10:00 a.m. (prevailing Eastern time)

February 14, 2007 at 10:00 a.m. (prevailing Eastern time)

March 1, 2007 at 10:00 a.m. (prevailing Eastern time)

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[1] Findings of fact shall be construed as conclusions of law and conclusions of law shall be construed as findings of fact when appropriate. See Fed. R. Bankr. P. 7052. Capitalized terms used and not otherwise defined herein shall have the meanings ascribed to them in the Motion.

March 21, 2007 at 10:00 a.m. (prevailing Eastern time)

April 5, 2007 at 10:00 a.m. (prevailing Eastern time)

April 27, 2007 at 10:00 a.m. (prevailing Eastern time)

May 10, 2007 at 10:00 a.m. (prevailing Eastern time)

May 24, 2007 at 10:00 a.m. (prevailing Eastern time)

June 1, 2007 at 10:00 a.m. (prevailing Eastern time)

June 14, 2007 at 10:00 a.m. (prevailing Eastern time)

June 22, 2007 at 10:00 a.m. (prevailing Eastern time)

July 12, 2007 at 10:00 a.m. (prevailing Eastern time)

July 20, 2007 at 10:00 a.m. (prevailing Eastern time)

August 2, 2007 at 10:00 a.m. (prevailing Eastern time)

August 17, 2007 at 10:00 a.m. (prevailing Eastern time)

August 30, 2007 at 10:00 a.m. (prevailing Eastern time)

September 28, 2007 at 10:00 a.m. (prevailing Eastern time)

October 11, 2007 at 10:00 a.m. (prevailing Eastern time)

October 26, 2007 at 10:00 a.m. (prevailing Eastern time)

November 8, 2007 at 10:00 a.m. (prevailing Eastern time)

November 30, 2007 at 10:00 a.m. (prevailing Eastern time)

December 6, 2007 at 10:00 a.m. (prevailing Eastern time)

2. Any response to a claims objection or an omnibus claims objection (a "Response") must (a) be in writing, (b) conform to the Federal Rules of Bankruptcy Procedure, the Local Bankruptcy Rules for the Southern District of New York, and the Amended Eighth Supplemental Order Under 11 U.S.C. §§ 102(1) And 105 And Fed. R. Bankr. P. 2002(m), 9006,

9007, And 9014 Establishing Omnibus Hearing Dates And Certain Notice, Case Management, And Administrative Procedures, entered on October 26, 2006 (the "Amended Eighth Supplemental Case Management Order") (Docket No. 5418), (c) be filed with the Bankruptcy Court in accordance with General Order M-242 (as amended) – registered users of the Bankruptcy Court's case filing system must file electronically, and all other parties-in-interest must file on a 3.5 inch disk (preferably in Portable Document Format (PDF), WordPerfect, or any other Windows-based word processing format), (d) be submitted in hard copy form directly to the chambers of the Honorable Robert D. Drain, United States Bankruptcy Judge, United States Bankruptcy Court for the Southern District of New York, One Bowling Green, Room 610, New York, New York 10004, and (e) be served upon (i) Delphi Corporation, 5725 Delphi Drive, Troy, Michigan 48098 (Att'n: General Counsel) and (ii) counsel to the Debtors, Skadden, Arps, Slate, Meagher & Flom LLP, 333 West Wacker Drive, Suite 2100, Chicago, Illinois 60606 (Att'n: John Wm. Butler, Jr., John K. Lyons, and Randall G. Reese), in each case so as to be received no later than 4:00 p.m. (prevailing Eastern time) on the seventh calendar day prior to the Omnibus Hearing for which the relevant claims objection or omnibus claims objection is scheduled.

3. Every Response must contain at a minimum the following:

(a) the title of the claims objection to which the Response is directed;

(b) the name of the claimant (each holder of a proof of claim, a "Claimant") and a brief description of the basis for the amount of the claim;

(c) a concise statement setting forth the reasons why the claim should not be disallowed, expunged, reduced, or reclassified, including, but not limited to, the specific factual and legal bases upon which the Claimant will rely in opposing the claims objection;

(d) unless already set forth in the proof of claim previously filed with the Court, documentation sufficient to establish a prima facie right to payment; provided, however, that the Claimant need not disclose confidential, proprietary, or otherwise protected information in the Response; provided further, however, that the Claimant shall disclose to the Debtors all information and provide copies of all documents that the Claimant believes to be

confidential, proprietary, or otherwise protected and upon which the Claimant intends to rely in support of its Claim, subject to appropriate confidentiality constraints;

(e) to the extent that the claim is contingent or fully or partially unliquidated, the amount that the Claimant believes would be the allowable amount of such claim upon liquidation of the claim or occurrence of the contingency, as appropriate; and

(f) the address(es) to which the Debtors must return any reply to the Response, if different from the address(es) presented in the claim.

4. Only those Responses made in writing and timely filed and received will be considered by the Court. If a Claimant whose proof of claim is subject to a claims objection and who is served with the relevant claims objection fails to file and serve a timely Response in compliance with the foregoing procedures, the Debtors may present to the Court an appropriate order seeking relief with respect to such claim consistent with the relief sought in the relevant claims objection without further notice to the claimant, provided that, upon entry of such an order, the claimant shall receive notice of the entry of such order as provided below; provided, however, that if the claimant files a timely Response, which does not include the required minimum information provided in paragraph 3 above, the Debtors shall seek disallowance and expungement of the relevant claim or claims only in accordance with the Claims Hearing Procedures provided in paragraph 9 below.

5. To the extent that a Response is filed with respect to any claim listed in a claims objection (each, a "Contested Claim"), each such Claim and the objection to such Claim asserted in the claims objection shall be deemed to constitute a separate contested matter as contemplated by Bankruptcy Rule 9014.

6. The Debtors are hereby authorized and directed to serve each Claimant whose proof of claim is listed in any omnibus claims objection with (a) a personalized Notice Of Objection To Claim which specifically identifies the Claimant's proof of claim that is subject to objection and the basis for such objection and (b) a complete copy of the relevant omnibus

claims objection without exhibits. Service of omnibus claims objections in such manner shall constitute good and sufficient notice and no other or further notice to claimants of an omnibus claims objection shall be required.

7. Kurtzman Carson Consultants, LLC (the "Claims Agent") is hereby authorized and directed to serve all orders entered with respect to any omnibus claims objections, including exhibits, upon only the master service list and the 2002 list. The Claims Agent is hereby further authorized and directed to serve all claimants whose proofs of claim are the subject of an order entered with respect to an omnibus claims objection with a copy of such order, without exhibits, and a personalized Notice Of Entry Of Order in the form attached hereto as Exhibit A specifically identifying such Claimant's proof of claim that is subject to the order, the Court's treatment of such proof of claim, and the basis for such treatment, and advising the Claimant of its ability to view the order with exhibits free of charge on the Debtors' Legal Information Website. Without limiting the foregoing, the Court hereby directs the Claims Agent to serve the First Omnibus Claims Order in the manner provided hereby.

8. Any order entered by the Court with respect to an objection asserted in an omnibus claims objection shall be deemed a separate order with respect to each claim covered by such order.

9. The following procedures shall apply with respect to the determination of Contested Claims (the "Claims Hearing Procedures"):

(a) Adjournment Of Claims Hearing.

(i) All Contested Claims for which a timely Response is filed shall be automatically adjourned to a future hearing, the date of which shall be determined by the Debtors, in their sole discretion, by serving the Claimant with notice as provided herein. The Debtors may send such notice to each Claimant when they deem it appropriate to do so, subject to the requirements of the Bankruptcy Code, the Bankruptcy Rules, and any further order of this Court.

The Debtors shall schedule the further hearing upon each Contested Claim to a Claims Hearing of the Debtors' election:

(A) for a non-evidentiary hearing to address the legal sufficiency of the particular proof of claim and whether the proof of claim states a claim against the asserted Debtor under Bankruptcy Rule 7012 (a "Sufficiency Hearing"), by serving upon the relevant Claimant by facsimile or overnight delivery, and filing with this Court, a notice substantially in the form attached hereto as Exhibit B (a "Notice Of Sufficiency Hearing") and a copy of this Order at least 20 business days prior to the date of such Sufficiency Hearing, or

(B) for an evidentiary hearing on the merits of such Contested Claim (a "Claims Objection Hearing"), by serving upon the relevant Claimant by facsimile or overnight delivery, and filing with this Court, a notice substantially in the form attached hereto as Exhibit C (a "Notice Of Claims Objection Hearing" and, collectively with the Notice of Sufficiency Hearing, the "Notices of Hearing") and a copy of this Order at least 65 calendar days prior to the date of such Claims Objection Hearing.

(ii) The Debtors, in their sole discretion, are authorized to further adjourn a hearing scheduled in accordance herewith at any time by providing notice to the Court and the Claimant at least five business days prior to the date of the scheduled hearing; provided, however, that the hearing on any Contested Claim shall not be adjourned for more than a total of 180 calendar days from date of service of the initial Notice of Hearing set forth in paragraph 9(a)(i)(A) and (B) above without consent of the Claimant with respect thereto, unless otherwise ordered by the Court.

(b) Sufficiency Hearing Procedures.

(i) To the extent that a Contested Claim is adjourned to a Sufficiency Hearing, if the Debtors wish to file a supplemental pleading, they shall file and serve their pleading no later than ten calendar days before the scheduled Sufficiency Hearing. The supplemental pleading shall not exceed fifteen single-sided, double-spaced pages.

(ii) To the extent that a Contested Claim is adjourned to a Sufficiency Hearing, if the Claimant wishes to file a supplemental response, the Claimant shall file and serve its response no later than two business days before the scheduled Sufficiency Hearing. The supplemental response shall not exceed fifteen single-sided, double-spaced pages.

(iii) To the extent that this Court determines upon conclusion of the Sufficiency Hearing that a Contested Claim cannot be disallowed in whole or in part without further proceedings, the Debtors shall provide to the Claimant a Notice Of Claims Objection Hearing pursuant to the procedures set forth above.

(c) Mandatory Meet And Confer.

(i) If (A) (1) the amount in dispute for a Contested Claim exceeds \$1,000,000 or (2) a Contested Claim asserts unliquidated claims (unless the Claimant irrevocably agrees in writing that the allowed amount of such Contested Claim shall be limited to a maximum of \$1,000,000), (B) the Claimant (if an individual) or the Claimant's principal place of

business (if a governmental unit or a person, as defined in section 101(41) of the Bankruptcy Code, other than an individual) is located within 90 miles of Troy, Michigan, and (C) such Contested Claim is scheduled by the Debtors for a Claims Objection Hearing, the Debtors and the relevant Claimant shall hold an in-person meet and confer (an "In-Person Meet and Confer") at a neutral location in Troy, Michigan, or such other location as is reasonably acceptable to the Debtors, within ten business days of service of the Notice Of Claims Objection Hearing.

(ii) If (A) (1) the amount in dispute for a Contested Claim is less than or equal to $1,000,000, (2) a Contested Claim asserts unliquidated claims and the Claimant with respect thereto irrevocably agrees in writing that the allowed amount of such Contested Claim shall be limited to a maximum of $1,000,000, or (3) the Claimant (if an individual) or the Claimant's principal place of business (if a governmental unit or a person, as defined in section 101(41) of the Bankruptcy Code, other than an individual) is located more than 90 miles from Troy, Michigan, and (B) such Contested Claim is scheduled by the Debtors for a Claims Objection Hearing, the Debtors and the relevant Claimant shall hold a telephonic meet and confer (a "Telephonic Meet and Confer" and, collectively with In-Person Meet and Confers, the "Meet and Confers") within ten business days of service of the Notice Of Claims Objection Hearing.

(iii) The following representatives of each of the Debtors and the Claimant shall attend the Meet and Confer: (A) counsel for each of the parties, except for a Claimant proceeding pro se, who shall be prepared to discuss the matter described in paragraph 9 (k) below, and (B) a person possessing ultimate authority to reconcile, settle, or otherwise resolve the Contested Claim on behalf of the Debtors and the Claimant, respectively; provided, however, that counsel for each of the parties may participate in the Meet and Confer telephonically.

(iv) The Court will consider appropriate sanctions, including allowance or disallowance of the Contested Claim, if either party does not follow the foregoing procedures or conduct the Meet and Confer in good faith.

(d) Debtors' Statement Of Disputed Issues. Within five business days after service of the Notice Of Claims Objection Hearing, the Debtors shall file and serve a written statement of disputed issues (the "Statement Of Disputed Issues") upon the Claimant. The Statement Of Disputed Issues shall contain a concise statement summarily setting forth the primary reasons why the claim should be disallowed, expunged, reduced, or reclassified as set forth in the claims objection, including, but not limited to, the material factual and legal bases upon which the Debtors will rely in prosecuting the claims objection, without prejudice to the Debtors' right to later identify and assert additional legal and factual bases for disallowance, expungement, reduction, or reclassification of the Contested Claim. The Statement of Disputed Issues shall also include documentation supporting the disallowance, expungement, reduction, or reclassification of the Contested Claim, without prejudice to the Debtors' right to later identify additional documentation supporting the disallowance, expungement, reduction, or reclassification of the Contested Claim; provided, however, that the Debtors need not disclose confidential, proprietary, or otherwise protected information in the Statement of Disputed Issues; provided further, however, that the Debtors shall disclose to the Claimant all information and

provide copies of all documents that the Debtors believe to be confidential, proprietary, or otherwise protected, subject to appropriate confidentiality constraints.

(e) Claimant's Supplemental Response. The following procedures apply to the Claimant's written supplemental response (the "Supplemental Response"), subject to modification pursuant to paragraph 9(k), filed in connection with a Claims Objection Hearing for a Contested Claim:

(i) The Claimant may file and serve its Supplemental Response (with a copy to chambers) no later than 30 business days prior to commencement of the Claims Objection Hearing. The Supplemental Response shall not exceed 20 single-sided, double-spaced pages (exclusive of exhibits or affidavits).

(ii) If the Claimant relies on exhibits, the Claimant shall include such exhibits in its Supplemental Response (other than those previously included with either its Proof of Claim or its Response); provided, however, that the Claimant need not disclose confidential, proprietary, or otherwise protected information in the Supplemental Response; provided further, however, that the Claimant shall disclose to the Debtors all information and provide copies of all documents that the Claimant believes to be confidential, proprietary, or otherwise protected and upon which the Claimant intends to rely in support of its Contested Claim, subject to appropriate confidentiality constraints. The Claimant shall include a certificate of counsel or a declaration or affidavit authenticating any documents attached to the Supplemental Response, as appropriate.

(iii) The Supplemental Response may include affidavits or declarations from no more than two witnesses setting forth the basis of the Contested Claim and evidence supporting the Contested Claim; provided, however, that if the Claimant intends to call a person not under such Claimant's control at the hearing, the Claimant shall, in lieu of an affidavit or declaration of such person, identify such person, the Claimant's basis for calling such person as a witness, and the reason that it did not file an affidavit or declaration of such person. If an affiant or declarant does not attend the Claims Objection Hearing, such affiant or declarant's affidavit or declaration shall be stricken. The Claimant shall not be permitted to elicit any direct testimony at the Claims Objection Hearing; instead, the affidavit or declaration submitted with the Supplemental Response, or such witnesses' deposition transcript if the witnesses were not under the Claimant's control, shall serve as the witnesses' direct testimony and the Debtors may cross examine the witnesses at the Claims Objection Hearing, or counter-designate deposition testimony. No other or additional witnesses may introduce evidence at the hearing on behalf of the Claimant.

(iv) No later than three business days prior to commencement of the Claims Objection Hearing, if the Claimant timely filed a Supplemental Response, the Claimant may file and serve (with a copy to chambers) an amended Supplemental Response and a supplemental affidavit or declaration on behalf of each of its witnesses solely for the purpose of supplementing the Supplemental Response and the witnesses' prior affidavits or declarations with respect to matters adduced through the discovery provided by these Claims Hearing Procedures; provided that the amended Supplemental Response shall be subject to the page limitations set forth above.

(f) Debtors' Supplemental Reply. The following procedures shall apply to the Debtors' written supplemental reply, if any (the "Supplemental Reply"), subject to modification pursuant to paragraph 9(k) below, filed in connection with a Claims Objection Hearing with respect to a Contested Claim:

(i) The Debtors may file and serve (with a copy to chambers) a Supplemental Reply no later than 20 business days prior to commencement of the Claims Objection Hearing. The Supplemental Reply shall not exceed 20 single-sided, double-spaced pages (exclusive of exhibits or affidavits).

(ii) If the Debtors rely on exhibits, the Debtors shall include such exhibits in their Supplemental Reply (other than those previously included with either their objection or reply); provided, however, that the Debtors need not disclose confidential, proprietary, or otherwise protected information in the Supplemental Reply; provided further, however, that the Debtors shall disclose to the Claimant all information and provide copies of all documents that the Debtors believe to be confidential, proprietary, or otherwise protected and upon which the Debtors intend to rely in support of their objection, subject to appropriate confidentiality constraints. The Debtors shall include a certificate of counsel or a declaration or affidavit authenticating any documents attached to the Supplemental Reply.

(iii) The Supplemental Reply may include affidavits or declarations from no more than two witnesses setting forth the Debtors' basis for objecting to the Contested Claim and evidence in support of such objection to the Contested Claim; provided, however, that if the Debtors intend to call a person not under the Debtors' control at the hearing, the Debtors shall, in lieu of an affidavit or declaration of such person, identify such person, the Debtors' basis for calling such person as a witness, and the reason that it did not file an affidavit or declaration of such person. If an affiant or declarant does not attend the Claims Objection Hearing, as appropriate, such affiant or declarant's affidavit or declaration shall be stricken. The Debtors shall not be permitted to elicit any direct testimony at the Claims Objection Hearing, instead, the affidavit or declaration submitted with the Supplemental Reply, or such witnesses' deposition transcript if the witnesses were not under the Debtors' control, shall serve as the witnesses' direct testimony and the Claimant may cross examine the witnesses at the Claims Objection Hearing or counter-designate deposition testimony. No other or additional witnesses may introduce evidence at the hearing on behalf of the Debtors.

(iv) No later than three business days prior to commencement of the Claims Objection Hearing, if the Debtors timely filed a Supplemental Reply, the Debtors may file and serve (with a copy to chambers) an amended Supplemental Reply and a supplemental affidavit or declaration on behalf of each of their witnesses solely for the purpose of supplementing the Supplemental Reply and the witnesses' prior affidavits or declarations with respect to matters adduced through the discovery provided by these Claims Hearing Procedures; provided that the amended Supplemental Reply shall be subject to the page limitations set forth above.

(g) Mandatory Non-Binding Summary Mediation. Except as set forth below, at least 15 business days prior to commencement of the Claims Objection Hearing, the Debtors and the Claimant shall submit to mandatory non-binding summary mediation (each, a

"Mediation") in an effort to consensually resolve the Contested Claim. The Mediation shall be governed by General Order M-143 except as follows. The following procedures shall apply to each Mediation, subject to modification pursuant to paragraph 9(k) below:

(i) Each Mediation shall be assigned to one of the mediators listed by the Debtors on Exhibit D hereto (each, a "Mediator"). The Debtors and the Claimant shall agree upon the Mediator at the Meet and Confer; provided that, if the Debtors and the Claimant are unable to agree upon a Mediator, the parties shall promptly report such inability to agree to the Court.

(ii) The Mediator shall not have the authority to require either the Debtors or the Claimant to provide any additional briefing with respect to the Mediation.

(iii) If (A) (1) the amount in dispute for a Contested Claim exceeds $1,000,000 or (2) a Contested Claim asserts unliquidated claims (unless the Claimant with respect thereto irrevocably agrees in writing that the allowed amount of such Contested Claim shall be limited to a maximum of $1,000,000) and (B) the Claimant (if an individual) or the Claimant's principal place of business (if a governmental unit or a person, as defined in section 101(41) of the Bankruptcy Code, other than an individual) is located within 90 miles of Troy, Michigan, the Mediation shall be held at a neutral location in Troy, Michigan.

(iv) If (A) (1) the amount in dispute for a Contested Claim exceeds $1,000,000 or (2) a Contested Claim asserts unliquidated claims (unless the Claimant with respect thereto irrevocably agrees in writing that the allowed amount of such Contested Claim shall be limited to a maximum of $1,000,000), and (B) the Claimant (if an individual) or the Claimant's principal place of business (if a governmental unit or a person, as defined in section 101(41) of the Bankruptcy Code, other than an individual) is located more than 90 miles from Troy, Michigan, the Mediation shall be held at a neutral location reasonably acceptable to the Debtors and the Claimant; provided that, if the Debtors and the Claimant are unable to agree upon a neutral location at the Meet and Confer, the parties shall promptly report such inability to agree to the Court.

(v) If (A) the amount in dispute for a Contested Claim is less than or equal to $1,000,000 or (B) the Contested Claim asserts unliquidated claims and the Claimant with respect thereto irrevocably agrees in writing that the allowed amount of such Contested Claim shall be limited to a maximum of $1,000,000, participation in Mediation shall be voluntary and any Mediation may be held telephonically at either the Debtors' or the Claimant's request.

(vi) A person possessing ultimate authority to reconcile, settle, or otherwise resolve the Contested Claim on behalf of each of the Debtors and the Claimant shall attend an in-person Mediation or participate in a telephonic Mediation, if any; provided, however, that the Debtors' counsel will not be precluded from attending and participating in a Mediation in the event that the claimant elects not to have its counsel attend or participate in a Mediation.

(vii) Absent consent of each of the Claimant and the Debtors, the length of the Mediation shall be limited to one day.

(viii) The Court will consider appropriate sanctions, including allowance or disallowance of the Contested Claim, if either party does not follow the foregoing procedures or conduct the Mediation in good faith.

(ix) The Debtors and the Claimant shall each bear its own costs in participating in the Mediation. The Debtors are hereby authorized to pay the Mediator's fees.

(h) Claims Objection Hearing Discovery. If a Claims Objection Hearing is scheduled for a particular Contested Claim, the Debtors and the Claimant shall be bound by the following discovery procedures, which shall otherwise be governed by the Bankruptcy Rules, subject to modification pursuant to paragraph 9(k) below:

(i) No later than five business days after service of the Supplemental Response, the Debtors may request:

(A) That the Claimant produce documents relevant to the Contested Claim. Documents shall be produced at least ten business days prior to commencement of the Claims Objection Hearing.

(B) That the Claimant respond to no more than 15 interrogatories, including discrete subparts. Responses shall be produced at least ten business days prior to commencement of the Claims Objection Hearing.

(C) That the Claimant respond to no more than ten requests for admission. Responses shall be produced at least ten business days prior to commencement of the Claims Objection Hearing.

(ii) No later than five business days after service of the Supplemental Reply, the Claimant may request:

(A) That the Debtors produce documents relevant to the Contested Claim. Documents shall be produced at least ten business days prior to commencement of the Claims Objection Hearing.

(B) That the Debtors respond to no more than 15 interrogatories, including discrete subparts. Responses shall be produced at least ten business days prior to commencement of the Claims Objection Hearing.

(C) That the Debtors respond to no more than ten requests for admission. Responses shall be produced at least ten business days prior to commencement of the Claims Objection Hearing.

(iii) No earlier than fifteen business days prior to the commencement of the Claims Objection Hearing, but at least five business days prior to commencement of the Claims Objection Hearing, the Debtors may, at their election, take the deposition upon oral examination of each witness whose affidavit or declaration was proffered in support of the Claimant's Supplemental Response. Each deposition shall not exceed three hours.

(iv) No earlier than fifteen business days prior to the commencement of the Claims Objection Hearing, but at least five business days prior to commencement of the Claims Objection Hearing, the Claimant may, at its election, take the deposition upon oral examination of each witness whose affidavit or declaration was proffered in support of the Debtors' Supplemental Reply. Each deposition shall not exceed three hours.

(v) Except as provided in paragraph 9(g)(vi) above, nothing in this Order alters any obligation of opposing counsel with regard to communications with non-counsel opponents or any applicable law regarding corporations or other business entities to be represented by counsel.

(i) Conduct Of The Claims Objection Hearing. The Debtors and the Claimant shall each be permitted, subject to modification pursuant to paragraph 9(k) below, no more than one hour to present their respective cases, inclusive of time cross-examining their opponent's witnesses and making argument to the Court. The parties shall coordinate with each other in advance of the hearing with respect to, joint exhibit binders, stipulated admission of evidence, anticipated disputes regarding the admission of particular evidence and any designated deposition testimony.

(j) Estimation Based Upon Claimant's Asserted Estimated Amount. To the extent that a Contested Claim would be subject to estimation pursuant to section 502(c) of the Bankruptcy Code and the Debtors have sought authority to estimate such Contested Claim pursuant to an omnibus claims objection and/or a motion to estimate claims, if the Claimant has filed a Response in accordance with the procedures outlined above which (i) acknowledges that the Contested Claim is contingent or fully or partially unliquidated and (ii) provides the amount that the Claimant believes would be the allowable amount of such Contested Claim upon liquidation of the Contested Claim or occurrence of the contingency, as appropriate (the "Claimant's Asserted Estimated Amount"), the Debtors are hereby authorized, in their sole discretion, to elect to provisionally accept the Claimant's Asserted Estimated Amount as the estimated amount of such Contested Claim pursuant to section 502(c) of the Bankruptcy Code for all purposes other than allowance, but including voting and establishing reserves for purposes of distribution, subject to further objection and reduction as appropriate and section 502(j) of the Bankruptcy Code. The Debtors' election shall be made by serving the Claimant with a Notice Of Election To Accept Claimant's Asserted Estimated Amount in the form attached hereto as Exhibit E. The Contested Claim will otherwise remain subject in all respects to the procedures outlined herein.

(k) Ability To Modify Procedures By Agreement Or Order Of Court. At the Meet and Confer, the parties shall discuss discovery parameters, briefing, evidence to be presented, the timing outlined herein, and any modifications thereto that are necessary due to the facts and circumstances of the relevant Contested Claim. Should the parties be unable to agree on reasonable modifications to these Claim Hearing Procedures, if any, either party may request that the Court promptly schedule a teleconference to consider such proposed modifications. No discovery, testimony, or motion practice other than that described herein, as modified, shall be permitted, unless otherwise agreed by the parties or ordered by the Court.

10. The procedures approved herein shall not apply to claims filed by Banc of America Securities LLC (as to proof of claim number 10758), Barclays Capital Inc. (as to proof of claim number 11658), Bear, Stearns & Co. Inc. (as to proof of claim number 10732), Cadence Innovation LLC, Citigroup Global Markets, Inc. (as to proof of claim number 10731), Credit Suisse Securities (USA) LLC (as to proof of claim number 10763), Merrill Lynch, Peirce, Fenner & Smith Inc. (as to proof of claim number 10761), Morgan Stanley & Co. Inc. (as to proof of claim number 10762), the Pension Benefit Guaranty Corporation, Robert Bosch GmbH, the State of California Environmental Protection Agency, the State of Michigan Environmental Protection Agency, the State of Ohio Environmental Protection Agency, Technology Properties, Ltd., UBS Securities LLC (as to proof of claim number 10759), the United States Environmental Protection Agency, and Wachovia Capital Markets, LLC (as to proof of claim number 10760) (collectively, the "Excluded Parties") for any purpose, including, but not limited to, any objections to such claims or other litigation in respect of such claims; provided, however, that nothing contained herein shall preclude any of the Excluded Parties or the Debtors, after notice and an opportunity to be heard, from seeking to establish appropriate alternative claims resolution procedures.

11. With respect to the claim of Gary Whitney ("Mr. Whitney") (claim number 10157) and NuTech Plastics Engineering, Inc. ("NuTech") (claim number 1279 against Delphi Automotive Systems LLC), nothing in this Order shall limit Mr. Whitney's or NuTech's ability to request relief from the automatic stay provisions under section 362 of the Bankruptcy Code subject to the Debtors' right to object to such request.

12. The Debtors shall not serve a Notice of Hearing on Orix Warren, LLC ("Orix Warren") with respect to proof of claim number 10202 until the earliest of the following

to occur: (a) the Debtors assume the lease between Delphi Automotive Systems LLC and Orix Warren with respect to property located at 4551 Research Parkway in Warren, Ohio (the "Orix Lease"), (b) the Debtors reject the Orix Lease, or (c) the Orix Lease terminates or is terminated pursuant to its terms.

13. Nothing in this Order shall preclude any right to seek estimation of a claim under section 502(c) of the Bankruptcy Code, any right to seek relief from the automatic stay under section 362 of the Bankruptcy Code to liquidate a claim in a different forum, any right to seek protection of information under section 107(b) of the Bankruptcy Code or any right not specifically addressed in this Order.

14. This Court shall retain jurisdiction to hear and determine all matters arising from the implementation of this order.

15. The requirement under Rule 9013-1(b) of the Local Bankruptcy Rules for the United States Bankruptcy Court for the Southern District of New York for the service and filing of a separate memorandum of law is deemed satisfied by the Motion.

Dated: New York, New York
December 6, 2006

/s/Robert D. Drain
UNITED STATES BANKRUPTCY JUDGE

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Delphi Legal Information Website:
http://www.delphidocket.com

UNITED STATES BANKRUPTCY COURT
SOUTHERN DISTRICT OF NEW YORK

- -	x	
	:	
In re	:	Chapter 11
	:	
DELPHI CORPORATION, et al.,	:	Case No. 05-44481 (RDD)
	:	
Debtors.	:	(Jointly Administered)
	:	
- -	x	

NOTICE OF ENTRY OF ORDER WITH RESPECT
TO [________] OMNIBUS CLAIMS OBJECTION

PLEASE TAKE NOTICE that on _____ _, 200_, the United States Bankruptcy Court for the Southern District of New York entered a [title of order] (the "Order").

PLEASE TAKE FURTHER NOTICE THAT a copy of the Order, excluding exhibits, is attached hereto.

PLEASE TAKE FURTHER NOTICE that the proof of claim listed below, which you filed against Delphi Corporation and/or other of its subsidiaries and affiliates that are debtors and debtors-in-possession in the above-captioned cases (collectively, the "Debtors"), was the subject of the Order and was listed on Exhibit __ to the Order and was accordingly disallowed and expunged, unless otherwise provided below in the column entitled "Treatment Of Claim."

Date Filed	**Claim Number**	**Asserted Claim Amount**[1]	**Basis For Objection**	**Treatment Of Claim**	**Surviving Claim Number (if any)**

[1] Asserted Claim Amounts listed as $0.00 generally reflect that the claim amount asserted is unliquidated.

PLEASE TAKE FURTHER NOTICE that you may view the complete exhibits to the Order by requesting a copy from the claims and noticing agent in the above-captioned chapter 11 cases, Kurtzman Carson Consultants LLC, at 1-888-259-2691 or by accessing the Debtors' Legal Information Website at www.delphidocket.com.

Dated: New York, New York
______ _, 200_

BY ORDER OF THE COURT

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UNITED STATES BANKRUPTCY COURT
SOUTHERN DISTRICT OF NEW YORK

- -	x	
	:	
In re	:	Chapter 11
	:	
DELPHI CORPORATION, et al.,	:	Case No. 05-44481 (RDD)
	:	
Debtors.	:	(Jointly Administered)
	:	
- -	x	

NOTICE OF HEARING WITH RESPECT TO
DEBTORS' OBJECTION TO PROOF OF CLAIM NO. [_____]

PLEASE TAKE NOTICE that on _____ _, 200_, Delphi Corporation and certain of its subsidiaries and affiliates, debtors and debtors-in-possession in the above-captioned cases

(collectively, the "Debtors"), objected to proof of claim number _____ (the "Proof of Claim") filed by ________ (the "Claimant") pursuant to the [Title Of Applicable Omnibus Claims Objection] (the "Objection").

PLEASE TAKE FURTHER NOTICE that pursuant to the Order Pursuant To 11 U.S.C. § 502(b) And Fed. R. Bankr. P. 2002(m), 3007, 7016, 7026, 9006, 9007, And 9014 Establishing (i) Dates For Hearings Regarding Objections To Claims And (ii) Certain Notices And Procedures Governing Objections To Claims, entered December __, 2006 (the "Order"), a sufficiency hearing (the "Sufficiency Hearing") to address the legal sufficiency of the Proof of Claim and whether the Proof of Claim states a colorable claim against the asserted Debtor is hereby scheduled for ________, 200_, at 10:00 a.m. (prevailing Eastern time) in the United States Bankruptcy Court for the Southern District of New York (the "Court").

PLEASE TAKE FURTHER NOTICE that the Sufficiency Hearing will proceed in accordance with the procedures provided in the Order, unless such procedures are modified in accordance with Paragraph 9(k) thereof. Please review the Order carefully – failure to comply with the procedures provided in the Order (or as modified pursuant to Paragraph 9(k)) could result in the disallowance and expungement of the Proof of Claim. A copy of the Order is attached hereto for your convenience.

PLEASE TAKE FURTHER NOTICE that the Debtors may further adjourn the Hearing at any time at least five business days prior to the scheduled hearing upon notice to the Court and the Claimant.

Dated: New York, New York
______ _, 200_

SKADDEN, ARPS, SLATE, MEAGHER &
FLOM LLP

By:___ _________________________
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Delphi Legal Information Website:
http://www.delphidocket.com

UNITED STATES BANKRUPTCY COURT
SOUTHERN DISTRICT OF NEW YORK

- -	x	
	:	
In re	:	Chapter 11
	:	
DELPHI CORPORATION, et al.,	:	Case No. 05-44481 (RDD)
	:	
Debtors.	:	(Jointly Administered)
	:	
- -	x	

NOTICE OF CLAIMS OBJECTION HEARING WITH
RESPECT TO DEBTORS' OBJECTION TO PROOF OF CLAIM NO. [_____]

PLEASE TAKE NOTICE that on _____ _, 200_, Delphi Corporation and certain of its subsidiaries and affiliates, debtors and debtors-in-possession in the above-captioned cases

(collectively, the "Debtors"), objected to proof of claim number _____ (the "Proof of Claim") filed by ________ (the "Claimant") pursuant to the [Title Of Applicable Omnibus Claims Objection] (the "Objection").

PLEASE TAKE FURTHER NOTICE that pursuant to the Order Pursuant To 11 U.S.C. § 502(b) And Fed. R. Bankr. P. 2002(m), 3007, 7016, 7026, 9006, 9007, And 9014 Establishing (i) Dates For Hearings Regarding Objections To Claims And (ii) Certain Notices And Procedures Governing Objections To Claims, entered December __, 2006 (the "Order"), a claims objection hearing (the "Claims Objection Hearing") for purposes of holding an evidentiary hearing on the merits of the Proof of Claim is hereby scheduled for _______, 200_, at 10:00 a.m. (prevailing Eastern time) in the United States Bankruptcy Court for the Southern District of New York (the "Court").

PLEASE TAKE FURTHER NOTICE that the Claims Objection Hearing will proceed in accordance with the procedures provided in the Order, unless such procedures are modified in accordance with Paragraph 9(k) thereof. Please review the Order carefully – failure to comply with the procedures provided in the Order (or as modified pursuant to Paragraph 9(k)) could result in the disallowance and expungement of the Proof of Claim. A copy of the Order is attached hereto for your convenience.

PLEASE TAKE FURTHER NOTICE that the Debtors may further adjourn the Hearing at any time at least five business days prior to the scheduled hearing upon notice to the Court and the Claimant.

Dated: New York, New York
______ _, 200_

SKADDEN, ARPS, SLATE, MEAGHER &
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EXHIBIT D

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Morton Collins
Susan Cook
Samuel Damren
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Erwin Katz
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Delphi Legal Information Website:
http://www.delphidocket.com

UNITED STATES BANKRUPTCY COURT
SOUTHERN DISTRICT OF NEW YORK

- -	x	
	:	
In re	:	Chapter 11
	:	
DELPHI CORPORATION, et al.,	:	Case No. 05-44481 (RDD)
	:	
Debtors.	:	(Jointly Administered)
	:	
- -	x	

NOTICE OF DEBTORS' ELECTION TO ACCEPT CLAIMANT'S
ASSERTED ESTIMATED AMOUNT FOR PROOF OF CLAIM NUMBER [______]

PLEASE TAKE NOTICE that on _____ _, 200_, Delphi Corporation and certain of its subsidiaries and affiliates, debtors and debtors-in-possession in the above-captioned cases

(collectively, the "Debtors"), objected to proof of claim number _____ (the "Proof of Claim") filed by ________ (the "Claimant") pursuant to the [Title Of Applicable Omnibus Claims Objection] (the "Objection").

PLEASE TAKE FURTHER NOTICE that on _____ _, 200_, the Claimant filed its response to the objection, wherein Claimant (i) acknowledged that the Proof of Claim asserts claims that are contingent or fully or partially unliquidated and (ii) stated that the Claimant believes that the allowable amount of the Proof of Claim upon liquidation of the Contested Claim or occurrence of the contingency, as appropriate, is $_______ (the "Claimant's Asserted Estimated Amount").

PLEASE TAKE FURTHER NOTICE that pursuant to the Order Pursuant To 11 U.S.C. § 502(b) And Fed. R. Bankr. P. 2002(m), 3007, 7016, 7026, 9006, 9007, And 9014 Establishing (i) Dates For Hearings Regarding Objections To Claims And (ii) Certain Notices And Procedures Governing Objections To Claims, entered December __, 2006 (the "Order"), the Debtors hereby provide notice that the Debtors elect to accept the Claimant's Asserted Estimated Amount as the estimated amount of the Proof of Claim pursuant to section 502(c) of the Bankruptcy Code as set forth in the Objection. A copy of the Order is attached hereto.

PLEASE TAKE FURTHER NOTICE that any hearing scheduled pursuant to the Order is hereby cancelled.

PLEASE TAKE FURTHER NOTICE that the Debtors' election to accept the Claimant's Asserted Estimated Amount is without prejudice to the Debtors' right to object to any other claims in these chapter 11 cases, or to further object to the Proof of Claim, on any grounds whatsoever.

Dated: New York, New York
______ _, 200_

SKADDEN, ARPS, SLATE, MEAGHER &
FLOM LLP

By:___________________________
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Debtors and Debtors-in-Possession

EXHIBIT I

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Response Service List

COMPANY	CONTACT	ADDRESS1	ADDRESS2	CITY	STATE	ZIP	PHONE	EMAIL	PARTY / FUNCTION
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JPMorgan Chase Bank, N.A.	Richard Duker	270 Park Avenue		New York	NY	10017	212-270-5484	richard.duker@jpmorgan.com	Prepetition Administrative Agent
JPMorgan Chase Bank, N.A.	Susan Atkins, Gianni Russello	277 Park Ave 8th Fl		New York	NY	10172	212-270-0426	gianni.russello@jpmorgan.com susan.atkins@jpmorgan.com	Postpetition Administrative Agent
Latham & Watkins LLP	Robert J. Rosenberg	885 Third Avenue		New York	NY	10022	212-906-1370	robert.rosenberg@lw.com	Counsel to Official Committee of Unsecured Creditors
Simpson Thatcher & Bartlett LLP	Kenneth S. Ziman, Robert H. Trust, William T. Russell, Jr.	425 Lexington Avenue		New York	NY	10017	212-455-2000	kziman@stblaw.com rtrust@stblaw.com wrussell@stblaw.com	Counsel to Debtor's Prepetition Administrative Agent, JPMorgan Chase Bank, N.A.
Skadden, Arps, Slate, Meagher & Flom LLP	John Wm. Butler, John K. Lyons, Ron E. Meisler	333 W. Wacker Dr.	Suite 2100	Chicago	IL	60606	312-407-0700	jbutler@skadden.com jlyonsch@skadden.com rmeisler@skadden.com	Counsel to the Debtor
Skadden, Arps, Slate, Meagher & Flom LLP	Kayalyn A. Marafioti, Thomas J. Matz	4 Times Square	P.O. Box 300	New York	NY	10036	212-735-3000	kmarafio@skadden.com tmatz@skadden.com	Counsel to the Debtor
United States Trustee	Alicia M. Leonhard	33 Whitehall Street	21st Floor	New York	NY	10004-2112	212-510-0500		Counsel to United States Trustee

Delphi Corporation
Special Parties

Company	Contact	Address1	Address2	City	State	Zip
Duanne Morris LLP	Walter J Greenhalgh Joseph H Lemkin	744 Broad St Ste 1200		Newark	NJ	07102-3889
Warner Norcross & Judd LLP	Gordon J Toering	900 Fifth Third Ctr	111 Lyon St NW	Grand Rapids	MI	49503-2487

EXHIBIT J

Delphi Corporation
Response Service List

COMPANY	CONTACT	ADDRESS1	ADDRESS2	CITY	STATE	ZIP	PHONE	EMAIL	PARTY / FUNCTION
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Delphi Corporation	Sean Corcoran, Karen Craft	5725 Delphi Drive		Troy	MI	48098	248-813-2000	sean.p.corcoran@delphi.com karen.j.craft@delphi.com	Debtors
Fried, Frank, Harris, Shriver & Jacobson	Brad Eric Sheler Bonnie Steingart Vivek Melwani Jennifer L Rodburg Richard J Slivinski	One New York Plaza		New York	NY	10004	212-859-8000	rodbuje@ffhsj.com sliviri@ffhsj.com	Counsel to Equity Security Holders Committee
JPMorgan Chase Bank, N.A.	Richard Duker	270 Park Avenue		New York	NY	10017	212-270-5484	richard.duker@jpmorgan.com	Prepetition Administrative Agent
JPMorgan Chase Bank, N.A.	Susan Atkins, Gianni Russello	277 Park Ave 8th Fl		New York	NY	10172	212-270-0426	gianni.russello@jpmorgan.com susan.atkins@jpmorgan.com	Postpetition Administrative Agent
Latham & Watkins LLP	Robert J. Rosenberg	885 Third Avenue		New York	NY	10022	212-906-1370	robert.rosenberg@lw.com	Counsel to Official Committee of Unsecured Creditors
Simpson Thatcher & Bartlett LLP	Kenneth S. Ziman, Robert H. Trust, William T. Russell, Jr.	425 Lexington Avenue		New York	NY	10017	212-455-2000	kziman@stblaw.com rtrust@stblaw.com wrussell@stblaw.com	Counsel to Debtor's Prepetition Administrative Agent, JPMorgan Chase Bank, N.A.
Skadden, Arps, Slate, Meagher & Flom LLP	John Wm. Butler, John K. Lyons, Ron E. Meisler	333 W. Wacker Dr.	Suite 2100	Chicago	IL	60606	312-407-0700	jbutler@skadden.com jlyonsch@skadden.com rmeisler@skadden.com	Counsel to the Debtor
Skadden, Arps, Slate, Meagher & Flom LLP	Kayalyn A. Marafioti, Thomas J. Matz	4 Times Square	P.O. Box 300	New York	NY	10036	212-735-3000	kmarafio@skadden.com tmatz@skadden.com	Counsel to the Debtor

Delphi Corporation
Special Parties

Company	Contact	Address1	Address2	City	State	Zip	Email
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Warner Norcross & Judd LLP	Gordon J Toering	900 Fifth Third Ctr	111 Lyon St NW	Grand Rapids	MI	49503-2487	gtoering@wnj.com

EXHIBIT K

Hearing Date And Time: July 20, 2007 at 10:00 a.m.

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UNITED STATES BANKRUPTCY COURT
SOUTHERN DISTRICT OF NEW YORK

In re	:	Chapter 11
DELPHI CORPORATION, et al.,	:	Case No. 05-44481 (RDD)
Debtor.	:	(Jointly Administered)

DEBTORS' OBJECTION TO ROBERT BOSCH GMBH'S MOTION TO
AMEND PROOF OF CLAIM

("OBJECTION TO BOSCH MOTION TO AMEND")

Delphi Corporation and certain of its subsidiaries and affiliates, debtors and debtors-in-possession in the above-captioned cases, including Delphi Automotive Systems LLC ("DAS LLC") (collectively, the "Debtors"), hereby object (the "Objection"), pursuant to rule 15 of the Federal Rules of Civil Procedure (the "Federal Rules") and rules 7015 and 9014 of the Federal Rules of Bankruptcy Procedures (the "Bankruptcy Rules") as applied through case law, to the Motion To Amend Proof Of Claim (Docket No. 8412) (the "Motion") filed by Robert Bosch GmbH ("Bosch GmbH"), and respectfully represent as follows:

Preliminary Statement

1. Bosch GmbH's proposed amendment does not relate back to its previously filed claims, and is an attempt to add an entirely new claim after the bar date in these cases has passed. Both the law and the equities demand that the amendment not be allowed.

2. On July 31, 2006, which was the bar date (the "Bar Date") in these cases, Bosch GmbH filed a proof of claim on account of alleged infringement of ten particular patents and asserting a claim "in excess of $15 million." Also on July 31, 2006, Robert Bosch Corporation ("Bosch U.S."), an affiliate of Bosch GmbH, filed a proof of claim asserting a claim more than $1.3 million on account of trade debt. On December 27, 2006, without leave of this Court and five months after the Bar Date, Bosch U.S. sought to amend its trade debt claim to allege infringement of three patents, two of which were previously included in Bosch GmbH's claim and one of which – the "New Patent Claim" – was never asserted in any prior claim filed by Bosch GmbH or Bosch U.S. The Debtors objected to both Bosch GmbH's and Bosch U.S.'s claims, challenging the validity of the claims and also challenging the timeliness of Bosch U.S.'s

late-filed claim. The hearing on those contested matters has been adjourned and will take place at a later time in accordance with the claims objection procedures approved by this Court.[1]

3. Furthermore, almost a year after the Bar Date, at least seven months after discovering that it may have an additional claim against the Debtors, and only after the Debtors had objected to Bosch U.S.'s claim as being untimely, among other things, Bosch GmbH for the first time filed a motion seeking authority to amend the Bosch GmbH Claim to include the New Patent Claim and "designate" Bosch U.S. as the holder of the two other patent claims in the Bosch GmbH proof of claim.

4. Through its Motion, Bosch is attempting to add an entirely new and distinct patent claim almost one year after the bar date has passed without any demonstration of why its neglect in failing to include the New Patent Claim in its original filing was excusable. Moreover, by seeking immediate relief from the Court, Bosch ignores the established claims procedures by demanding an immediate adjudication as to whether the late filed New Patent Claim should be allowed to stand. This matter is already the subject of an omnibus objection that the Debtors filed more than two months ago and is currently slated to be resolved in accordance with the claims procedures.

5. The Second Circuit has stated that courts must engage in a two-part inquiry when considering amendments to claims. First, they must examine whether the amendment relates back to a timely-filed claim. Second, if the amendment does relate back, courts must examine whether it would be equitable to allow the amendment. See Midland Cogeneration Venture Ltd. P'ship v. Enron Corp. (In re Enron Corp.), 419 F. 3d 115, 133 (2d Cir.

[1] See Order Pursuant To 11 U.S.C. § 502(b) And Fed. R. Bankr. P. 2002(m), 3007, 7016, 7026, 9006, 9007, And 9014 Establishing (i) Dates For Hearings Regarding Objections To Claims And (ii) Certain Notices And Procedures Governing Objections to Claims (Docket No. 6089).

2005) (hereafter, "Enron Corp. (Midland)"). As more fully explained below, Bosch GmbH's motion to amend its claim fails both of these inquiries. Accordingly, the Motion should be denied.

Statement Of Facts

A. Procedural History

6. On July 31, 2006, Bosch GmbH timely filed proof of claim no. 13623 ("Proof of Claim 13623") against DAS LLC, asserting claims "in excess of $15 million" for alleged prepetition patent infringement of ten patents (US-5,482,314, US-6.422.596, EP-434.679, DE-199.581.61, EP-458.796, DE-4.040.927, DE-196.514.52, DE-3.729.785, EP-1066174; EP-757.635). Also on July 31, 2006, Bosch U.S. filed proof of claim no. 13620 ("Proof of Claim 13620"), asserting a trade debt claim in the amount of $1,333,984.29 for parts sold and delivered to DAS LLC. On August 16, 2006, Bosch GmbH amended Proof of Claim 13623 by filing proof of claim number 16220 (the "Bosch GmbH Claim").[2]

7. On October 31, 2006 the Debtors objected to the Bosch GmbH Claim on the grounds that the Debtors believe they owe no liability to Bosch GmbH. On November 22, 2006, Bosch GmbH responded to the Debtors' objection. As a result, the hearing on the merits of the Bosch GmbH claim was adjourned pursuant to the claims objection procedures.

8. By its own admission,[3] some time after the Bar Date and prior to November 22, 2006 Bosch GmbH came to believe the Debtors may have also infringed another

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[2] The Debtors entered into a stipulation with Bosch GmbH to disallow and expunge duplicative claims filed by Bosch GmbH, leaving the Bosch GmbH Claim (proof of claim no. 16220) as the surviving claim. In the stipulation, the parties agreed that, if Bosch GmbH amended its claim to assert additional or different obligations, it need only amend the surviving claim. In all stipulations between the Debtors and Bosch GmbH or Bosch U.S., however, the Debtors have specifically reserved their rights to object to any new claims or amendments on any basis, including but not limited to timeliness. See Docket Nos. 6637, 7598, 7691.

[3] See Motion at ¶ 23.

patent, US 6,272,411 (the "New Patent"), which previously was not listed on the Bosch GmbH Claim. Bosch GmbH apparently also discovered that three patents (the New Patent and two of the patents included in the Bosch GmbH Claim) were actually held by Bosch U.S. rather than Bosch GmbH. Without seeking leave of this Court, on December 27, 2006, Bosch U.S. filed proof of claim no. 16467 (the "Amended Bosch U.S. Claim"), purporting to amend Proof of Claim 13620, a trade debt claims asserting a claim in excess of $1.3 million, to include a claim of more than $15 million for alleged patent infringement by the Debtors. The Amended Bosch U.S. Claim alleged infringement of the three patents discovered to be held by Bosch U.S., including the New Patent and two of the patents that were included in the Bosch GmbH Claim.

9. On April 27, 2007, the Debtors objected to the Amended Bosch U.S. Claim as untimely and unsubstantiated, and on May 23, 2007, Bosch U.S. filed a response thereto. Accordingly, pursuant to the claims objection procedures approved by this Court, the Amended Bosch U.S. Claim is currently adjourned to a future date to be noticed by the Debtors. The identity of the holder and owner of the patents and the merits of the infringement claims will be decided by this Court at a hearing to be noticed by the Debtors.

10. Not until June 28, 2007, after waiting more than ten months after filing the Bosch GmbH Claim, almost a year after the Bar Date, and only after the Debtors had objected to the Amended Bosch U.S. Claim, did Bosch GmbH file the Motion to seek leave to amend the Bosch GmbH Claim to include the New Patent and "designate" Bosch U.S. as the holder of three patents.

11. By the Motion, Bosch GmbH seeks to (i) revise the name of the claimant for certain patent infringement claims and (ii) add the New Patent to the list of patents allegedly infringed by the Debtors. As a threshold matter, the issue of whether Bosch U.S. can assert a claim against the Debtors for infringement of the three patents that it holds, including the New

Patent, is already pending before this Court. This issue was raised in the Debtors' objection to the Amended Bosch U.S. Claim and will be addressed by the Debtors in accordance with the claims objection procedures approved by this Court. Therefore, it is the second issue, i.e., whether Bosch GmbH can assert a claim for the New Patent, that has not previously been raised before this Court.[4] As discussed below, such claim should not be permitted.

B. The Relevant Patents

12. The ten patents included in the Bosch GmbH Claim generally relate to two different product lines, occupant detection devices and airbag control modules. See Supporting Declaration of William Cosnowski, Jr. (the "Cosnowski Decl."), at ¶ 6. These two product lines are entirely different. The occupant detection devices are installed within the seat of a vehicle and are designed to identify whether the occupant in the front passenger seat is the size of a child or an adult and accordingly determine whether the airbag should be suppressed. The airbag control module is a computer that evaluates vehicle safety data and controls airbag deployment when an impact occurs. Id.

13. Even within each product line, each patent each covers a separate device or process. Although Patent US-5,482,314 and the New Patent both cover occupant detection processes; these patents set forth claims on unique inventions. See id. at ¶ 7. Generally, Patent US-5,482,314 includes at least a six-step process to use sensors to develop a set of electrical signals and then evaluates those signals to potentially generate a de-activate signal for the passive restraint signal in a specific manner using specific criteria. See id. at ¶ 7. In contrast, the

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4 It is unclear what legal effect Bosch GmbH intends by "designating" Bosch U.S. as the holder of certain claims. Even if Bosch GmbH is allowed to "designate" Bosch U.S. as the holder of the two patents already included in the Bosch GmbH Claim, the issue of whether that designation allows Bosch GmbH to recover damages for any alleged infringement of those patents is one to be decided by this Court on the merits and pursuant to the claims objection procedures. Moreover, regardless of whether the New Patent is designated as held by Bosch GmbH or Bosch U.S., the claim on account of the New Patent is an untimely, new claim and therefore should not be allowed.

New Patent generally uses at least a three-step process in which sensors periodically provide data that is then compared with a historical database to determine if there is a change in occupancy that may correspond to preselected criteria for signals to the passive restraint system. See id. at ¶ 7 .

Argument

14. Bosch GmbH's proposed amendment to its claim fails to satisfy the Second Circuit's two-step inquiry to determine whether a post-bar date amendment to a proof of claim should be permitted. To allow an amendment to a proof of claim after the bar date has passed, courts first look to whether the amendment relates back to a timely-filed claim. See Enron Corp. (Midland), 419 F.3d at 134. The party asserting the relation-back bears the burden of proof. See Enron Creditors Recovery Corp., __ B.R. __, 2007 WL 1705653, at *4 (Bankr. S.D.N.Y. June 13, 2007) (hereafter, "Enron Creditors Recovery"). If an amendment relates back, then the court "will examine each fact within the case and determine whether it would be equitable to allow the amendment." Enron Corp. (Midland), 419 F.3d at 133. Bosch GmbH's proposed amendment does not relate back to the Bosch GmbH Claim. As discussed above, Bosch GmbH's proposed amendment would add a new, unique patent infringement claim for which Bosch GmbH would need to demonstrate a completely different set of facts than those needed to prove infringement of the other patents asserted in the Bosch GmbH Claim. Additionally, to defend the alleged infringement of the New Patent, the Debtors will need to develop and introduce unique facts to support their defenses of patent invalidity and inequitable conduct, which will be different from the facts to be raised by the Debtors to prove invalidity of the other patents asserted in the Bosch GmbH Claim. Moreover, even if the proposed amendment is found to relate back to the Bosch GmbH Claim, it would be inequitable to allow

the proposed amendment because both the Debtors and other creditors would be prejudiced by the amendment. Therefore, Bosch GmbH's Motion should be denied.

A. Bosch GmbH's Proposed Amendment Arises From Different Facts And Thus Cannot Relate Back To The Bosch GmbH Claim

15. In determining whether a proposed amendment relates back to an original claim, courts must "take care that an amendment would truly amend a timely filed proof of claim rather than assert a new claim." Enron Creditors Recovery, 2007 WL 1705653 at *3; see also Enron Corp. (Midland), 419 F.3d at 133 (quoting In re Integrated Res., Inc. v. Amertrust Co. Nat'l Ass'n (In re Integrated Res., Inc.), 157 B.R. 66, 70 (S.D.N.Y. 1993)) ("the court must subject post bar date amendments to careful scrutiny to assure that there was no attempt to file a new claim under the guise of an amendment"). A proposed amendment may be allowed if it corrects a defect of form in the original claim, describes the original claim with greater particularity, or pleads a new theory of recovery on the facts set forth in the original claim. See Enron Corp. (Midland), 419 F.3d at 133 (quoting In re McLean Indus., Inc., 121 B.R. 704, 708 (Bankr. S.D.N.Y. 1990)); In re Asia Global Crossing, Ltd., 325 B.R. 503, 507 (Bankr. S.D.N.Y. 2005) (hereafter, "Asia Global Crossing").

16. To analyze whether an amendment relates back to the original timely-filed claim, courts have applied rule 15(c) of the Federal Rules ("Rule 15(c)") pursuant to Bankruptcy Rules 7015 and 9014(c). See Enron Creditors Recovery, 2007 WL 1705653 at *4; see also Enron Corp. (Midland), 419 F.3d at 133; Asia Global Crossing., 324 B.R. at 508; In re Enron Corp., 328 B.R. 75, 87 (Bankr. S.D.N.Y. 2005). Rule 15(c) provides that an amendment relates back when "the claim or defense asserted in the amended pleading arose out of the conduct, transaction, or occurrence set forth or attempted to be set forth in the original pleading . . . ." Fed. R. Civ. P. 15(c)(2). This means that "the court must decide whether there is a sufficient

commonality of facts between the allegations relating to the two causes of action to preclude the claim of unfair surprise." Asia Global Crossing, 324 B.R. at 508 (citing Benfield v. Mocatta Metals Corp., 26 F.3d 19, 23 (2d Cir. 1994)). "The court should also consider whether the defendant had notice of the claim now being asserted, and whether the plaintiff will rely on the same type of evidence to prove both claims." Id.

17. By attempting to add the New Patent to the list of patents included in the Bosch GmbH Claim, Bosch GmbH is asserting a new claim that does not relate back to a prior one. The claim on account of the alleged infringement of the New Patent does not "arise out of the same occurrence set forth in the original pleading," as required by Rule 15(c). Thus, it cannot relate back to a timely-filed claim. Although Bosch GmbH asserts in the Motion that its proposed amendment "simply . . . [adds] a related patent that was previously omitted from the list of airbag technology patents" in the Bosch GmbH Claim, the New Patent actually applies to a process not covered by any of the patents named in the Bosch GmbH Claim.

18. Bosch GmbH attempts to generalize by asserting that all of the patents were infringed by "the Debtors' sale of Electronic Control Units and/or detection devices (collectively, 'ECUs')," Motion at ¶ 1. However, each patent covers a separate and distinct device or process. Thus, Bosch GmbH will need to provide different evidence against each allegedly infringing product with respect to each patent that has allegedly been infringed. See Cosnowski Decl. at ¶ 9, 10. Furthermore, to defend each patent infringement claim, the Debtors will likely present unique evidence to support the Debtors' interpretations of the claims in the patent and demonstrate that the various allegedly infringing products differ from the required elements of the asserted patent claims. See id. at ¶ 11. Even if the underlying products produced by the Debtors were the same in each case (which they are not), comparing the products to each patent requires demonstration of different facts to determine whether any alleged infringement

has occurred. Moreover, the Debtors also possess different statutory and equitable defenses, including patent invalidity, inequitable conduct, and laches, all of which will require facts particular to the New Patent and different from the facts the Debtors would offer against the patents identified in the Bosch GmbH Claim. See Cosnowski Decl. at ¶ 12. The lack of commonality of facts necessary to establish or defend against a claim of infringement on both the New Patent and the various other patents included in the Bosch GmbH Claim demonstrate that the proposed amendment does not relate back the original claim.

19. A claim does not relate back to an earlier claim if both claims require proof of different facts, even if there are similarities on the surface of both claims. In In re W.T. Grant Co., 53 B.R. 417 (Bankr S.D.N.Y. 1985), the claimant negotiated a financing transaction with the debtor and leased two properties to the debtor. The debtor separately rejected each of the two leases before the bar date. The claimant timely filed a rejection damages claim for one of the rejected leases and then, 16 months after the bar date, sought to amend the claim to include rejection damages for the second lease. Although both claims arose from the same financing arrangement and both claims were for lease rejection damages, albeit for different properties, the court did not permit the post-bar date amendment. The court found that the lease provisions were distinct from one another: they were not coterminous, rent was separate, notice of termination of one lease did not terminate the other, and the leases were separately assignable or could be sublet to different parties. Id. at 421.

20. Here, the alleged infringement of the New Patent may give rise to a cause of action similar to the alleged infringement of one of the patents listed in the Bosch GmbH Claim, just as the rejection of the two leases gave rise to a similar cause of action for rejection

damages.[5] Yet, the W.T. Grant court noted that the claims were "separate and distinct" from one another. Id. at 420. Furthermore, the court reasoned that the terms and provisions contained in each lease were different and "lead [the] court to conclude that they are distinct from each other." Id. at 421. Here, the processes protected by the New Patent are separate and distinct from the other patents included in the Bosch GmbH Claim. To prove an infringement of the New Patent, Bosch GmbH would need to establish different facts than with respect to the patents asserted in the Bosch GmbH Claim.

21. Like the claimant in W.T. Grant, Bosch GmbH seeks to add a similar, but unique, claim to its original proof of claim. The Bosch GmbH Claim and the proposed amendment both allege patent infringement, but the claims arise from different patents covering unique inventions. Some of the ten patents included in the Bosch GmbH Claim apply to a product line of occupant detection devices (patents US-5,482,314, EP-757.635, and the New Patent, US-6,272,411, together, the "Occupant Detection Patents"), while others relate to air bag control modules (patents US-6,422,596, EP-434.679, DE-199.581.61, EP-458.796, DE-4.040.927, DE-196.514.52, DE-3.729.785, and EP-1066174, together, the "Airbag Control Module Patents").[6] See Cosnowski Decl. at ¶¶ 6, 7. As described above, these two products lines are completely different.

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[5] Patent rights are often equated to real property deeds and contracts: "[A] patent may be thought of as a form of deed which sets out the metes and bounds of the property the inventor owns for the term and puts the world on notice to avoid trespass or to enable one to purchase all or part of the property right it represents. The public holds a vested future interest in the property. Accordingly, patents should be interpreted under the same rules as govern interpretation of kindred documents." Markman v. Westview Instruments, Inc., 52 F.3d 967, 997 (Fed. Cir. 1995).

[6] Bosch GmbH's Motion identifies the allegedly infringing product as electronic control units or "ECUs". ECU is a generic and overly simplistic term which does not properly identify or classify Debtor's accused products. See Cosnowski Decl. at ¶ 6.

22. Within those two product lines, some patents cover processes and others cover particular devices. Even among those that cover processes, the processes protected by each patent are different from each other and require a showing of distinct infringing actions or elements. Here, the New Patent covers inventions relating to an occupant detection process which is in an entirely different technology area than the inventions covered by the Airbag Control Module Patents. Id. at ¶¶ 5, 6. Among the Occupant Detection Patents, Patent EP-757.635 covers devices and methods (and applies only in Europe), while Patents US-5,482,314 and the New Patent cover distinct processes. Id. at ¶ 7.

23. Even between Patent US-5,482,314 and the New Patent, the patented processes are completely distinct and require proof of entirely different steps that comprise the patented process. See id. at ¶ 7. The methods behind these two patents, as described above, are completely different and would require Bosch GmbH to prove the existence of unique features for each patent claim and defend against unique challenges against the validity of each of the patents that will be raised by the Debtors. Thus, the proposed amendment to include a claim based on this New Patent does not relate back to the Bosch GmbH Claim.

B. The Equitable Factors Preclude Bosch GmbH's Proposed Amendment

24. The Debtors maintain that Bosch GmbH's proposed amendment does not relate back to the Bosch GmbH Claim, and therefore the court need not even consider the equitable factors. See Enron Creditors Recovery, 2007 WL 1705653 at *3; Asia Global Crossing, 324 B.R. at 507. Even if this Court finds, however, that Bosch GmbH's proposed amendment relates back to the Bosch GmbH Claim, the equitable balancing factors weigh in favor of the Debtors and should preclude allowing the proposed amendment to the original claim. See, e.g., Enron Corp. (Midland), 419 F.3d at 134 (even assuming that claim related back, amendment must fail when factors under equitable test weigh heavily against it).

25. If the first prong of the analysis is satisfied and the claim is found to "relate back" to the timely filed claim, a court must then balance the equities by considering the following five factors: (1) undue prejudice to the opposing party, (2) bad faith or dilatory behavior on the part of the claimant, (3) whether other creditors would receive a windfall if the amendment is not allowed, (4) whether other claimants might be harmed or prejudiced, and (5) the justification for the inability to file the amended claim at the time the original claim was filed. See Enron Creditors Recovery, 2007 WL 1705653 at *3; In re Integrated Res., Inc., 157 B.R. at 70; In re PT-1 Communications, Inc., 292 B.R. 482, 487 (Bankr. E.D.N.Y. 2003). Here, at least four of the five factors weigh heavily in favor of the Debtors and against allowing the amendment. Thus Bosch GmbH's Motion must be denied.

(i) The Debtors Will Be Prejudiced If Bosch GmbH's Amendment Is Allowed

26. When balancing the equities, the Second Circuit has emphasized that "the critical consideration is whether the opposing party will be unduly prejudiced by the amendment." Enron Corp. (Midland), 419 F.3d at 133 (quoting In re Integrated Res., Inc., 157 B.R. at 70). The considerations in weighing the prejudice to the Debtors include the size of the claim, the Debtors' knowledge of the claim, and the threat of a flood of similar claims. Enron Corp. (Midland), 419 F.3d at 130, 133-34 (explaining the prejudice factor in the context of a late claim but noting that a similar analysis applies for an amended claim).

27. Bosch GmbH summarily concludes that the Debtors will suffer no prejudice by allowance of the amendment. This is not true. Allowing Bosch GmbH to amend its claim would likely "precipitate a flood of similar claims" for several reasons. See Enron Corp. (Midland), 419 F.3d at 130. Although the size of Bosch GmbH's claim may be small in relation to the total value of the claims filed in the bankruptcy cases, a claim in excess of $15 million is

large in absolute terms. See id. (noting that claim of $12.5 million in a $900 billion bankruptcy is "no small amount" in absolute terms); see also In re Kmart Corp., 381 F.3d 709, 714 (7th Cir. 2004) (finding that allowing $750,000 claim with claim pool of approximately $6 billion could easily cause debtor "to find itself faced with a mountain of such claims, with a corresponding price tag in the millions of dollars"). Also, adding the New Patent, another avenue of recovery, increases Bosch GmbH's total potential recovery, notwithstanding Bosch's assertion that it has not changed the claimed amount in the Bosch GmbH Claim, an amount the Debtors believe is wildly inflated.[7] Moreover, the aggregate value of all additional patent claims, not to mention claims in general, that might be asserted as amendments modeled after the Motion could be quite substantial.

28. Courts have often looked primarily to concerns about opening the floodgates to similar late-filed claims as a reason not to allow an amendment. See, e.g., Enron Corp. (Midland), 419 F.3d at 132; In re Kmart Corp., 381 F.3d at 714 (noting that if court allowed all similar late-filed claims, "Kmart could easily find itself faced with a mountain of such claims"); Enron Creditors Recovery, 2007 WL 1705653 at *10-11 ("It can be presumed in a case of this size with tens of thousands of filed claims, there are other similarly-situated potential claimants. . . . Any deluge of motions seeking similar relief would prejudice the Debtors' reorganization process." (citation omitted)).

29. Furthermore, allowing Bosch GmbH to amend a timely-filed claim after the Debtors objected to a related claim as untimely could open the floodgates for all claimants who face a similar timeliness objection to seek leave to amend after the fact. The monetary consequences of such a flood of motions to amend claims and the potentially significant

[7] If Bosch GmbH believed that the addition of the New Patent to its claim would not yield any additional recovery, it would likely not have taken the time to seek leave to do so.

administrative burden on the Debtors would pose a threat of severe undue prejudice to the Debtors, thus weighing against allowing Bosch GmbH's proposed amendment.

(ii) Other Creditors Would Not Receive A Windfall If The Amendment Is Not Allowed

30. As noted above, Bosch GmbH would likely recover a greater amount if it could amend its claim to include the New Patent than it would without adding that claim. Although other creditors may receive an increased distribution if the amendment is not allowed, such a distribution would not constitute a windfall given the expected size of the claims pool in these cases. Therefore, this factor weighs in favor of the Debtors. See Enron Creditors Recovery, 2007 WL 1705653 at *6.

(iii) Other Creditors May Be Prejudiced If The Debtors Are Prevented From Administering The Estate

31. In addition to the Debtors being prejudiced by both the financial cost and administrative burden of facing a flood of motions to amend claims, other claimants in these cases would also be prejudiced by allowance of Bosch GmbH's proposed amendment. Litigating such motions before the merits of pending objections have been determined, which may obviate the need for amendment, is a waste of the Debtors' resources. Not only is that a costly prospect, but it prevents the Debtors from administering the claims process according to their plan to reach their goal of determining the value of the claims pool to obtain their exit financing and emerge from chapter 11. See Enron Creditors Recovery, 2007 WL 1705653 at *6 (noting that prejudice to Debtors "would also impede the administration of the estate, thus causing harm and prejudice to other claimants, and therefore weighs in favor of the Debtors").

(iv) Bosch GmbH Has Provided No Justification For Its Delay In Seeking To Amend Its Claim

32. Bosch GmbH points out that Bosch U.S. filed an amendment to its original claim more quickly after learning of the possibility that certain patents were held by Bosch U.S. rather than Bosch GmbH. Bosch GmbH, however, provides no explanation for why it did not seek to amend its own claim until now. Bosch GmbH states that the Motion was filed now "because Bosch does not know when the Debtors will schedule the hearing on the objection [to the Amended Bosch U.S. Claim]. It may be months or even years from now. The longer Bosch GmbH waits to amend its claim, the more it will appear at first blush to be untimely. Bosch GmbH simply cannot risk waiting any longer." Motion at ¶ 44. This unpersuasive effort to justify Bosch GmbH's filing the Motion now does not explain why the Motion was not filed sooner. The Bar Date passed more than eleven months ago. Bosch GmbH admitted in its Motion that it realized in November 2006 that it might have an infringement claim based on the New Patent. Nevertheless, Bosch GmbH does not explain why it waited seven months to seek to amend its claim to account for this new information.

33. The fact that the Motion was filed before the Debtors have filed a plan of reorganization is also inconclusive. The suggestion that adding a claim after the bar date, but before a plan has been filed, is not a disruption "ignores the arduous process of valuing assets, validating claims, and negotiating a compromise among a host of creditors," because the claim is "nonetheless submitted long after the negotiations required to develop [a] plan ha[ve] begun." Enron Corp. (Midland), 419 F.3d at 129. Bosch GmbH's delay, therefore, weighs against allowing the amendment.

34. Without addressing Bosch GmbH's motives or good faith in filing the Motion, four of the five equitable factors set forth in the second part of the Second Circuit analysis to determine whether an amended proof of claim should be allowed weigh against allowing the amendment. Even if this Court finds that the proposed amendment relates back to a

timely-filed proof of claim, Bosch GmbH's amendment fails the second prong of the amendment test.

Conclusion

35. Bosch GmbH seeks to amend its claim to add a completely new claim eleven months after the Bar Date and approximately seven months after it became aware of the facts giving rise to the requested amendment. Bosch GmbH fails both prongs of the Second Circuit's test for amending claims because Bosch GmbH's proposed amended claim does not relate back to the Bosch GmbH Claim and the equitable factors do not favor amendment. Accordingly, the Motion should be denied.

Memorandum Of Law

36. Because the legal points and authorities upon which this Objection relies are incorporated herein, the Debtors respectfully request that the requirement of the service and filing of a separate memorandum of law under Local Rule 9013-1(b) of the Local Bankruptcy Rules for the United States Bankruptcy Court for the Southern District of New York be deemed satisfied.

WHEREFORE the Debtors respectfully request that the Court enter an order (a) denying the Motion and (b) granting them such other and further relief as is just.

Dated: New York, New York
July 13, 2007

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EXHIBIT L

Hearing Date And Time: July 20, 2007 at 10:00 a.m.

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UNITED STATES BANKRUPTCY COURT
SOUTHERN DISTRICT OF NEW YORK

In re	:	Chapter 11
DELPHI CORPORATION, et al.,	:	Case No. 05-44481 (RDD)
Debtor.	:	(Jointly Administered)

DECLARATION OF WILLIAM COSNOWSKI, JR. IN SUPPORT OF DEBTORS' OBJECTION TO ROBERT BOSCH GMBH'S MOTION TO AMEND PROOF OF CLAIM

("COSNOWSKI DECLARATION – OBJECTION TO BOSCH MOTION")

I, William Cosnowski, Jr., declare as follows:

1. I serve as Divisional Counsel for Delphi Electronic and Safety, the business unit responsible for manufacture and sale of the accused products of Delphi Corporation and certain of its subsidiaries and affiliates, debtors and debtors-in-possession in these chapter 11 cases (collectively, the "Debtors"). I am also litigation and intellectual property counsel to the Debtors. I have been employed by the Debtors for the past five years.

2. I submit this declaration in support of the Debtors' Objection To Robert Bosch GmbH's Motion To Amend Proof Of Claim (the "Objection"), dated July 13, 2007. Capitalized terms not otherwise defined in this declaration have the meanings ascribed to them in the Objection.

3. Except as otherwise indicated, all facts set forth in this declaration are based upon my personal knowledge, my review of relevant documents, and my experience with and knowledge of the following patents: US-5,482,314, US-6.422.596, EP-434.679, DE-199.581.61, EP-458.796, DE-4.040.927, DE-196.514.52, DE-3.729.785, EP-1066174, EP-757.635, and US 6,272,411. If I were called upon to testify, I could and would testify to the facts set forth herein.

<u>Patents – Unique Inventions</u>

4. A patent for an invention is the grant of a property right to the inventor that is issued by the United States Patent and Trademark Office. The right conferred by the patent grant is not the right to make, use, sell, or import, but "the right to exclude others from making, using, offering for sale, or selling" the invention in the United States or "importing" the invention into the United States.

5. Inventors may obtain patents with claims directed to protect (i) devices or apparatuses or (ii) processes and methods. Device/apparatus claims cover inventions directed to the structural and functional aspects of physical products, objects, and/or systems. Process/method claims cover inventions directed to steps for using and performing an arrangement of tasks to accomplish a defined purpose.

6. Bosch GmbH's Motion identifies the products that allegedly infringe the patents as electronic control units or "ECUs." ECU is a generic and overly simplistic term which does not properly identify or classify the Debtors' products. Instead, the products that Bosch GmbH alleges infringe its patents relate to either occupant detection systems or airbag control modules, which are two distinct product lines. The occupant detection devices are installed within the seat of a vehicle and are designed to identify whether the occupant in the front passenger seat is the size of a child or an adult and accordingly determine whether the passenger airbag should be suppressed. The airbag control module is a computer that evaluates vehicle safety data and that triggers air bag system deployment when there is an impact.

7. Three of the eleven patents allegedly infringed apply to occupant detection devices (patents US-5,482,314, EP-757.635, and US-6,272,411 (the "New Patent"), collectively, the "Occupant Detection Patents"), while the other eight patents cover air bag control modules, (patents US-6,422,596, EP-434.679, DE-199.581.61, EP-458.796, DE-4.040.927, DE-196.514.52, DE-3.729.785, and EP-1066174, the "Airbag Control Module Patents"). Although patent US-5,482,314, a copy of which is attached hereto as Exhibit A, and patent US-6,272,411, a copy of which is attached here to as Exhibit B, cover occupant detection processes, they are unique inventions. See Comparison Of Patents Chart, attached hereto as Exhibit C. Generally, patent US 5,482,314 includes at least a six-step process to use sensors to develop a set of electrical signals and then evaluates those signals to potentially generate a de-activate signal for

the passive restraint signal in a specific manner using confidence values, fused features, empirical relationships, and other criteria. See Exhibit A at 25. In contrast, the New Patent generally uses at least a three-step process in which sensors periodically provide data that is then compared with a historical database to determine if there is a change in occupancy that may correspond to preselected criteria for signals to the passive restraint system. See Exhibit B at 26.

8. Infringement is determined by the language of the claims, which are the parts of a patent which define the boundaries of the patent's protection. If a product or method does not fall within the specific language of all properly interpreted claim elements of the patent, there is no literal infringement. Even where no literal infringement exists, an accused product may infringe a patent under the doctrine of equivalents. The doctrine of equivalents permits courts to extend the scope of protection beyond the claim's literal meaning in certain circumstances where a substitute element in the accused product matches the function, way, and result of the claimed element and where the substitute element in the accused product is only insubstantially different from the claimed element in the asserted patent. In both cases, under either literal infringement or infringement under the doctrine of equivalents, the determination of infringement requires fact intensive analysis.

9. Here, the New Patent is distinct from the other patents listed in the Bosch GmbH Claim. The six claims of the New Patent are unique, distinct, and cover different inventions from all of the other claims set forth in the other asserted patents. To demonstrate infringement on the New Patent, Bosch GmbH would need to establish a completely different set of facts than those needed to prove other patent infringement claims asserted in the Bosch GmbH Claim. For Bosch GmbH to successfully prosecute a patent infringement claim with respect to the New Patent, Bosch GmbH must at least demonstrate that the Debtors' occupant detection product falls within the language of the three elements identified in the first claim of the New

Patent. These three elements in the first claim define the boundaries of the claimed invention and the New Patent's protection, which does not overlap with the factual analysis that would be necessary to determine infringement of any other patents held by Bosch GmbH and identified in the Bosch GmbH Claim. Additionally, to defend against the alleged infringement of the New Patent will require the Debtors to develop and introduce unique facts to support its defenses of patent invalidity and inequitable conduct, which will be different from the facts to be raised by the Debtors to prove invalidity of the other patents asserted in the Bosch GmbH Claim.

10. The evidence necessary to establish infringement of the New Patent will likely include facts relating to construction/interpretation of the elements of the claims in the patent, proofs of the alleged literal infringement (i.e., comparing each element of each asserted patent claim to the corresponding feature or structure in the accused products), and proofs of alleged infringement under the doctrine of equivalents (i.e., identifying equivalents to the claim elements in the accused product and determining if insubstantial differences exist).

11. To defend each patent infringement claim, the Debtors will present unique evidence to support the Debtors' interpretations of the claims in the patent and to demonstrate that the characteristics of the various accused products differ from the required elements of the asserted patent either literally or under the doctrine of equivalents.

12. The Debtors will be able to assert statutory and equitable defenses, including but not limited to patent invalidity, inequitable conduct, and latches, all of which will require facts exclusive to challenge the New Patent that are different from the facts the Debtors would offer against the patents identified in the Bosch GmbH Claim.

I declare under penalty of perjury, pursuant to 28 U.S.C. § 1746, that the foregoing statements are true and correct.

/s/ William Cosnowski, Jr.
William Cosnowski, Jr.

Dated this 13th day of July, 2007

EXHIBIT A

Patent US-5,482,314

US005482314A

United States Patent [19]

Corrado et al.

[11] **Patent Number: 5,482,314**

[45] **Date of Patent: Jan. 9, 1996**

[54] **AUTOMOTIVE OCCUPANT SENSOR SYSTEM AND METHOD OF OPERATION BY SENSOR FUSION**

[75] Inventors: **Anthony P. Corrado**, Upland; **Stephen W. Decker**, La Crescenta; **Paul K. Benbow**, Upland, all of Calif.

[73] Assignee: **Aerojet General Corporation**, Fairlawn, Ohio

[21] Appl. No.: **227,531**

[22] Filed: **Apr. 12, 1994**

[51] **Int. Cl.**^{6} **B60R 21/32**

[52] **U.S. Cl.** **280/735**; 364/424.05; 307/10.1

[58] **Field of Search** .... 280/735, 734, 280/728 R, 730 R, 731, 732, 728.1, 730.1; 180/272; 307/10.1; 364/424.05; 340/565

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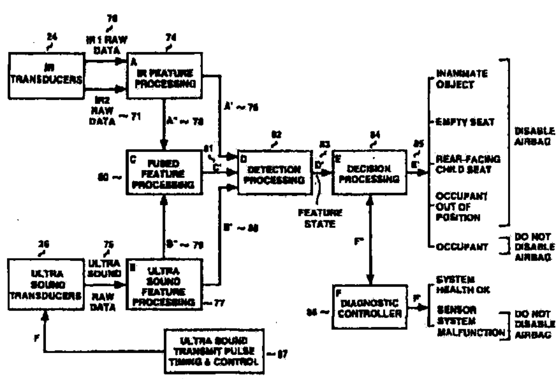
Primary Examiner—Margaret A. Focarino
Assistant Examiner—Peter C. English
Attorney, Agent, or Firm—Jacques M. Dulin

[57] **ABSTRACT**

A system for sensing the presence, position and type of an occupant in a passenger seat of a vehicle, as well as for sensing the presence of a rear-facing child seat therein, for use in enabling or disabling a related airbag activator. The sensor system employs sensor-fusion, a process of combining information provided by two or more sensors, each of which "sees" the world in a unique sense. In a preferred embodiment, occupancy sensor samples two detectable properties, a first being a thermal signature and associated motion, and a second is acoustically measured distance and the associated motion. Infrared sensor inputs and an ultrasonic sensor input are combined in a microprocessor circuit by means of a sensor fusion algorithm to produce an output signal to the air bag controller. The output signal results from preselected confidence weighing for feature parameters generated by the two sensors and upon a fusion process which ultimately makes a decision which is extremely reliable. The sensor fusion matrix processes the sensor outputs in a decision making operation which includes weighing inputs to guarantee reliability. All sensor outputs, along with calibration data, initial conditions and historical reference data are considered in the process of making a decision of whether or not to deploy the passenger-side air bag in a collision.

65 Claims, 17 Drawing Sheets



SIGNAL PROCESSOR FUNCTIONAL BLOCK DIAGRAM

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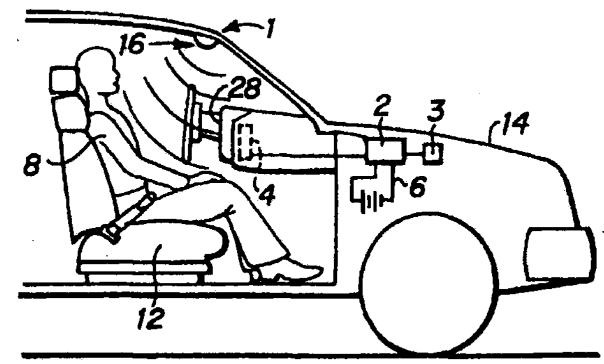
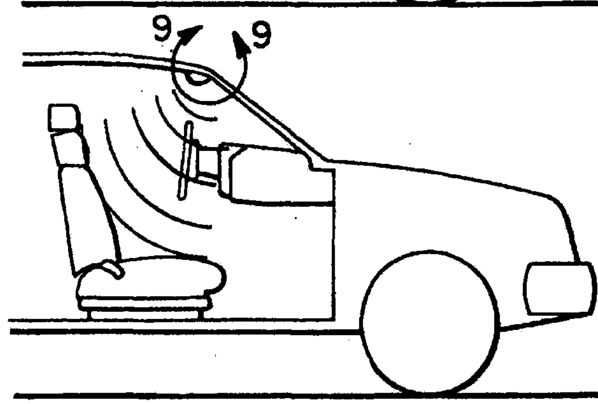


Fig_1



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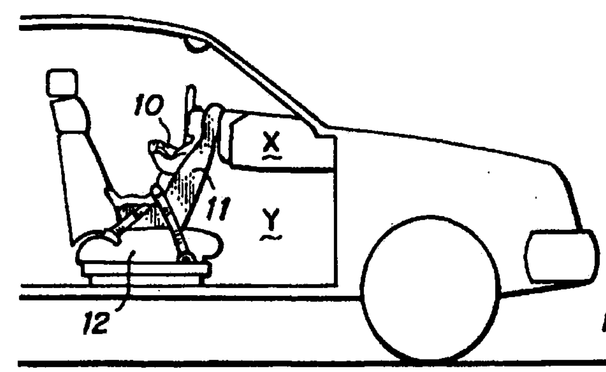

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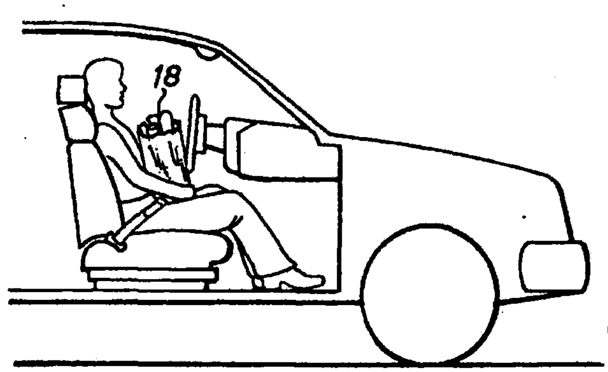

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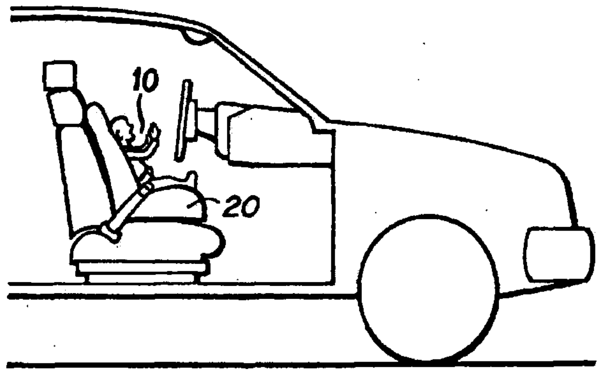


Fig_5

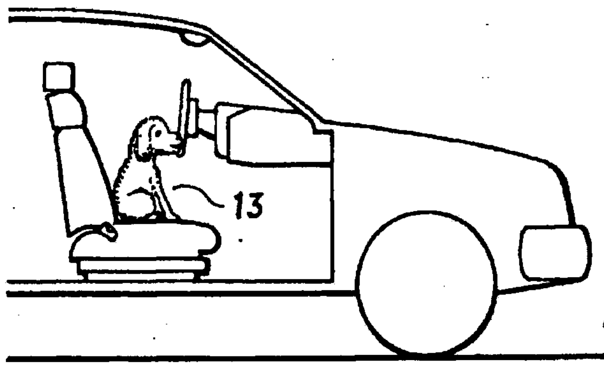


Fig_6

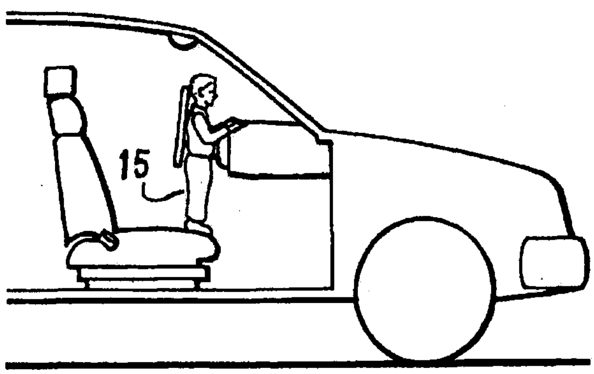


Fig.7

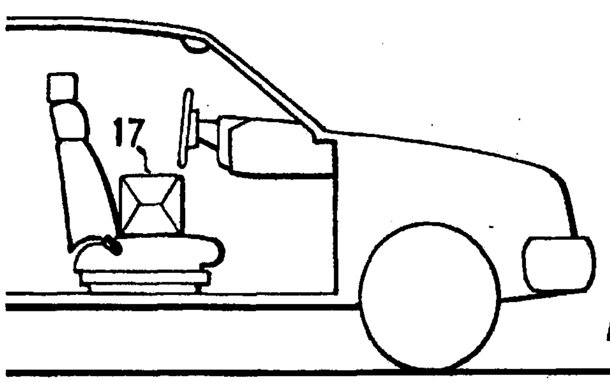


Fig.8

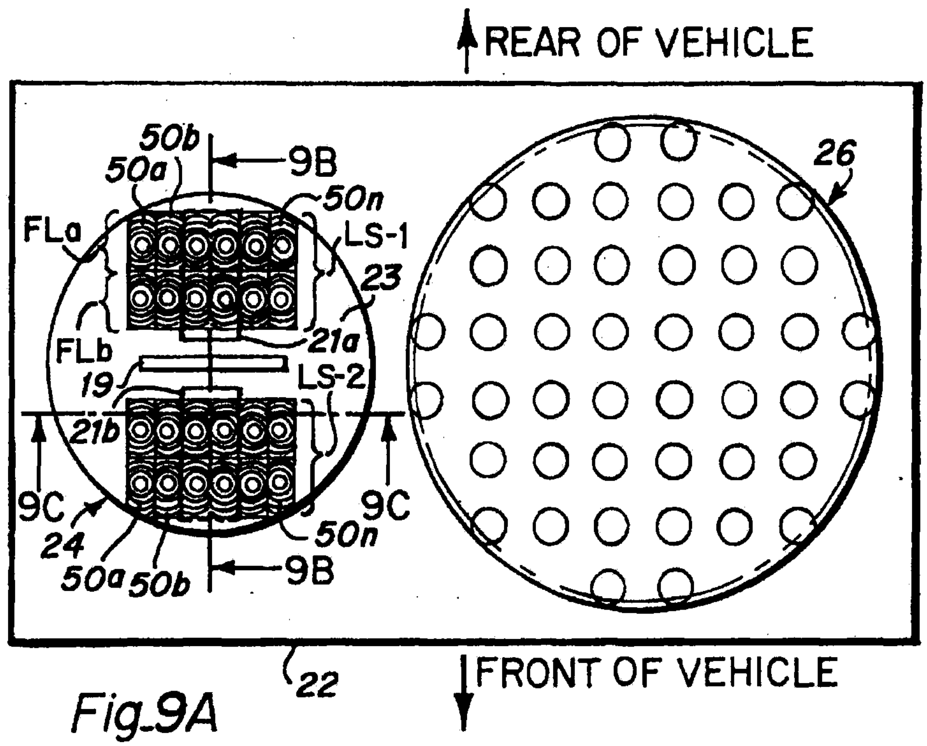


Fig_9A

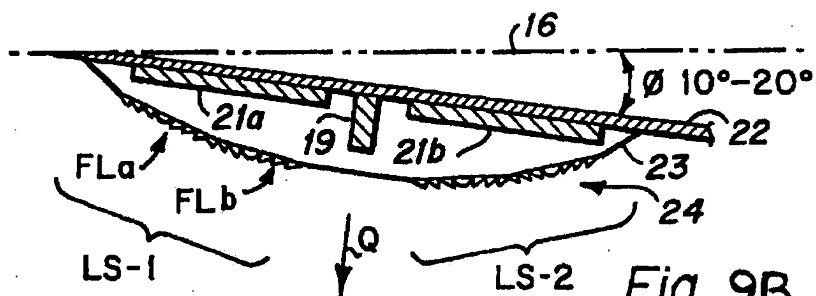


Fig_9B

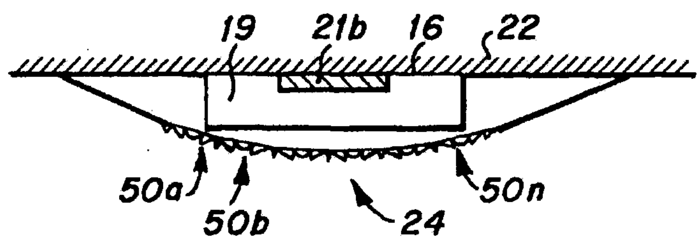
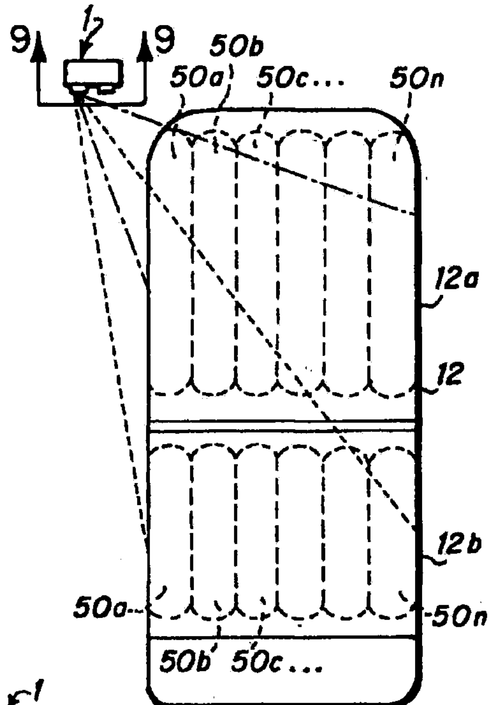


Fig_9C



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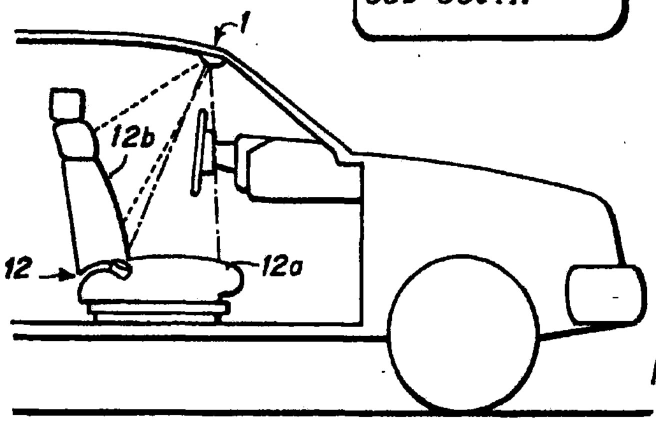


Fig_11a

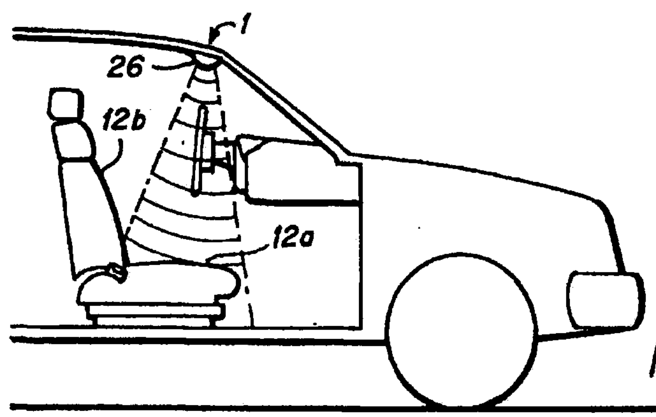


Fig_11b

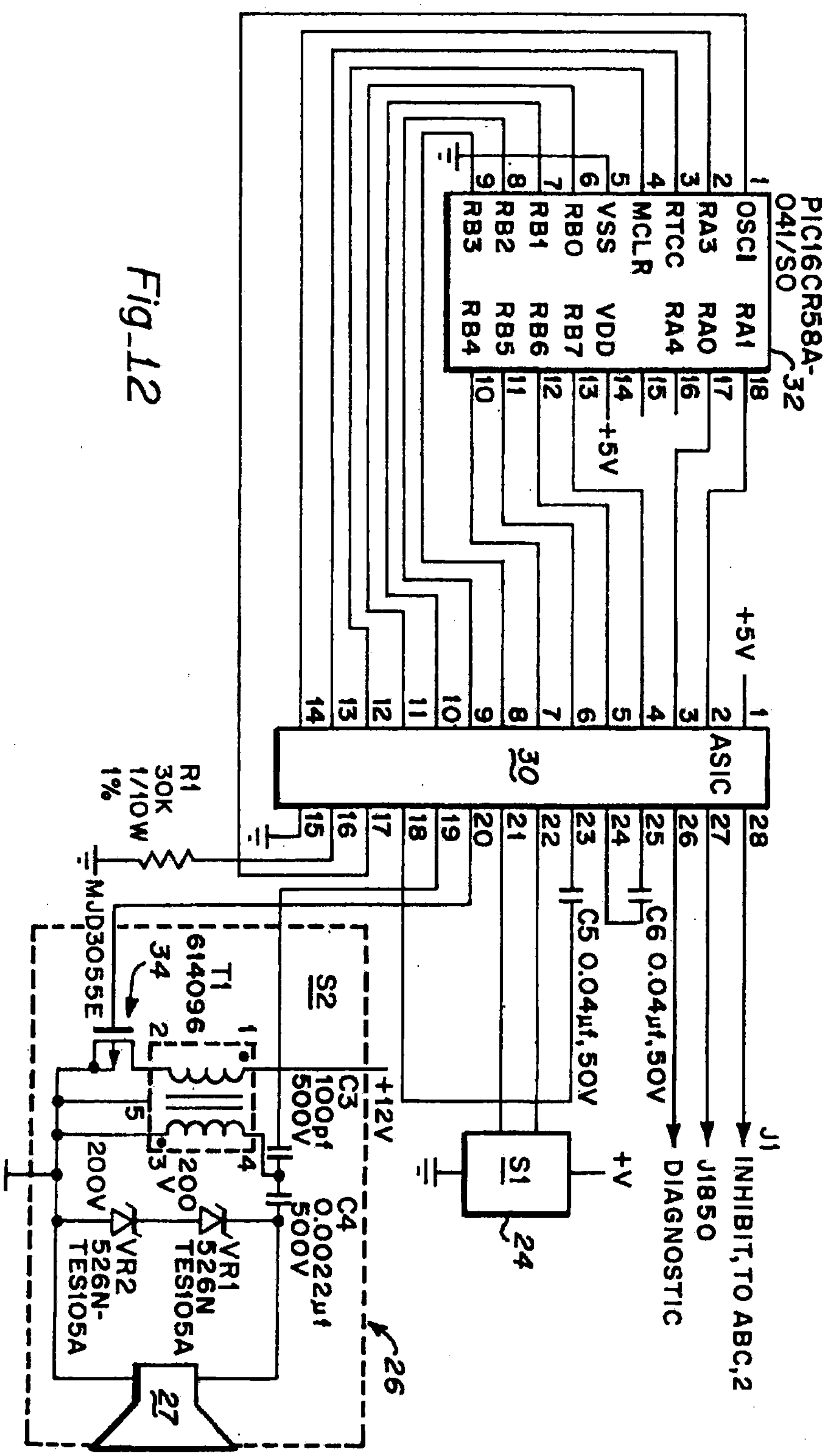

PIC16CR58A-
041/SO
32
OSCI
RA3
RTCC
MCLR
VSS
RB0
RB1
RB2
RB3
RA1
RA0
RA4
VDD
RB7
RB6
RB5
RB4
+5V
+5V
ASIC
30
R1
30K
1/10W
1%
MJD3055E
34
T1
614096
S2
+12V
C3
100pf
500V
C4
0.0022µf
500V
200V
200
3V
VR1
526N
TES105A
VR2
526N-
TES105A
27
26
S1
+V
24
C5 0.04µf,50V
C6 0.04µf,50V
J1
INHIBIT,TO ABC,2
J1850
DIAGNOSTIC

Fig_12

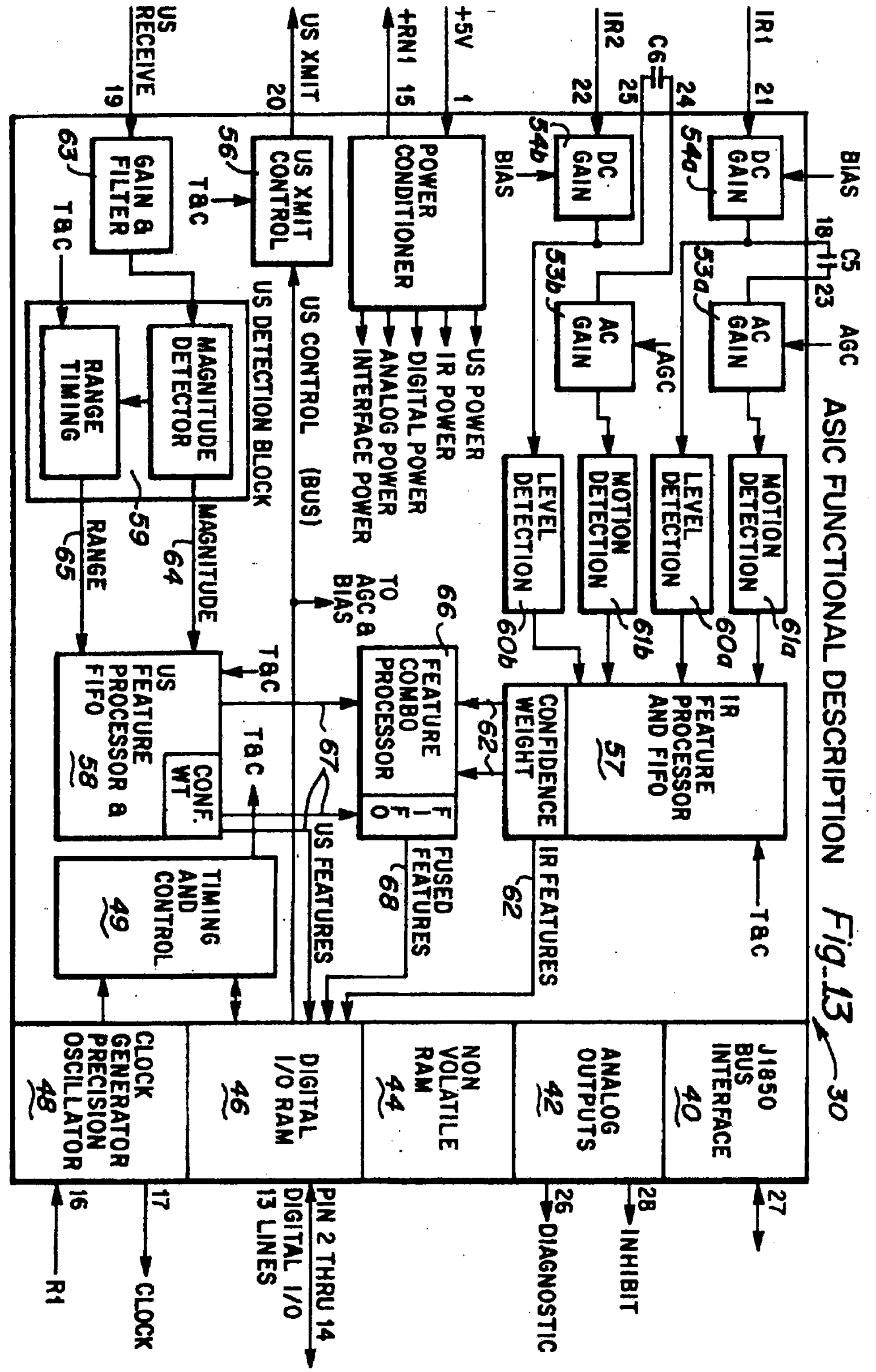

ASIC FUNCTIONAL DESCRIPTION
IR1
IR2
C6
+5V
+RN1
US XMIT
US RECEIVE
BIAS
DC GAIN
AC GAIN
AGC
C5
MOTION DETECTION
LEVEL DETECTION
IR FEATURE PROCESSOR AND FIFO
57
CONFIDENCE WEIGHT
FEATURE COMBO PROCESSOR
FIFO
POWER CONDITIONER
US POWER
IR POWER
DIGITAL POWER
ANALOG POWER
INTERFACE POWER
US XMIT CONTROL
T&C
GAIN & FILTER
MAGNITUDE DETECTOR
RANGE TIMING
US DETECTION BLOCK
US CONTROL (BUS)
TO AGC & BIAS
MAGNITUDE
RANGE
US FEATURE PROCESSOR & FIFO
58
CONF. WT
TIMING AND CONTROL
49
US FEATURES
FUSED FEATURES
IR FEATURES
J1850 BUS INTERFACE
40
ANALOG OUTPUTS
42
NON VOLATILE RAM
44
DIGITAL I/O RAM
46
CLOCK GENERATOR PRECISION OSCILLATOR
48
INHIBIT
DIAGNOSTIC
PIN 2 THRU 14 DIGITAL I/O 13 LINES
CLOCK
R1
30

Fig.13

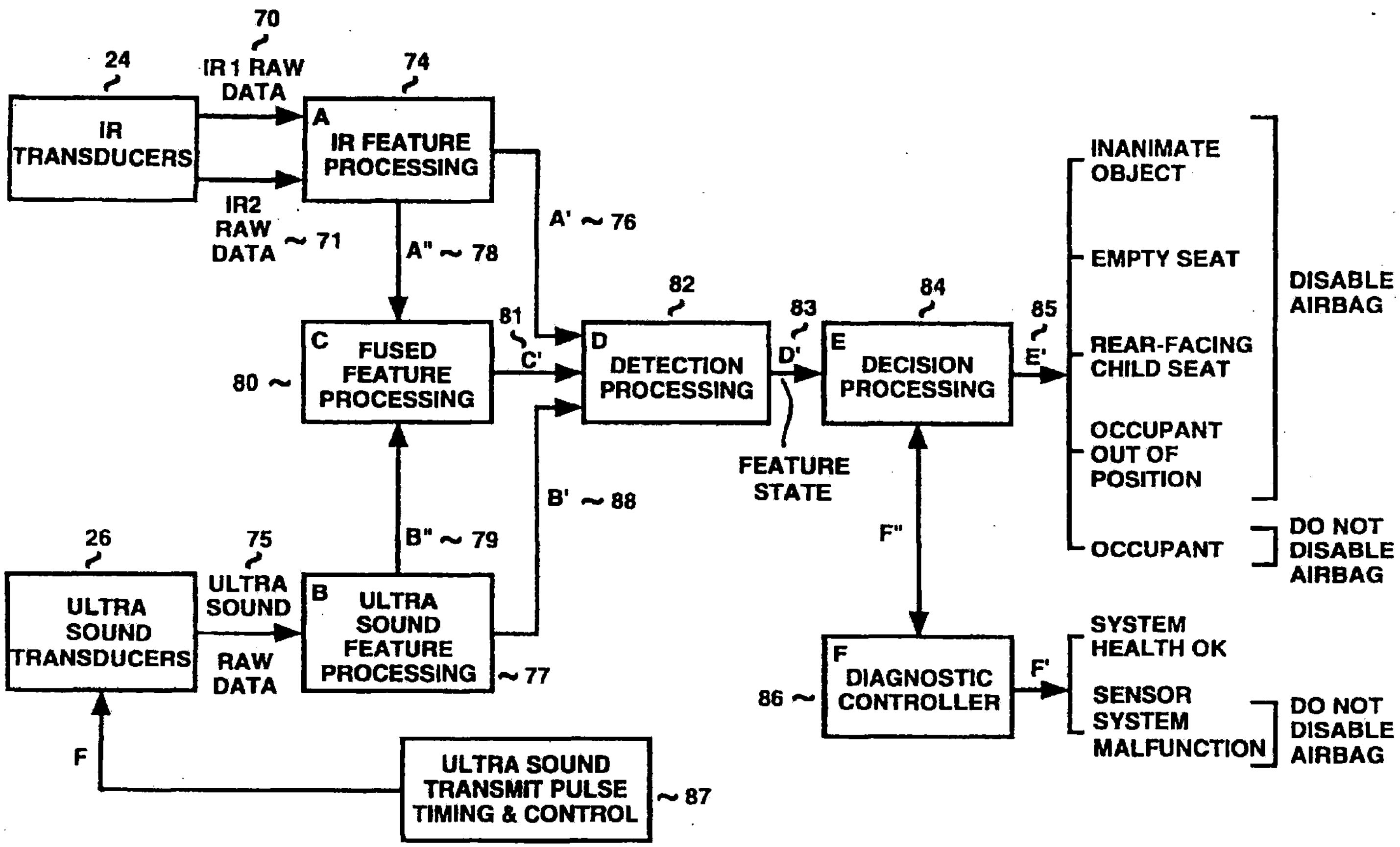


Fig. 14 SIGNAL PROCESSOR FUNCTIONAL BLOCK DIAGRAM

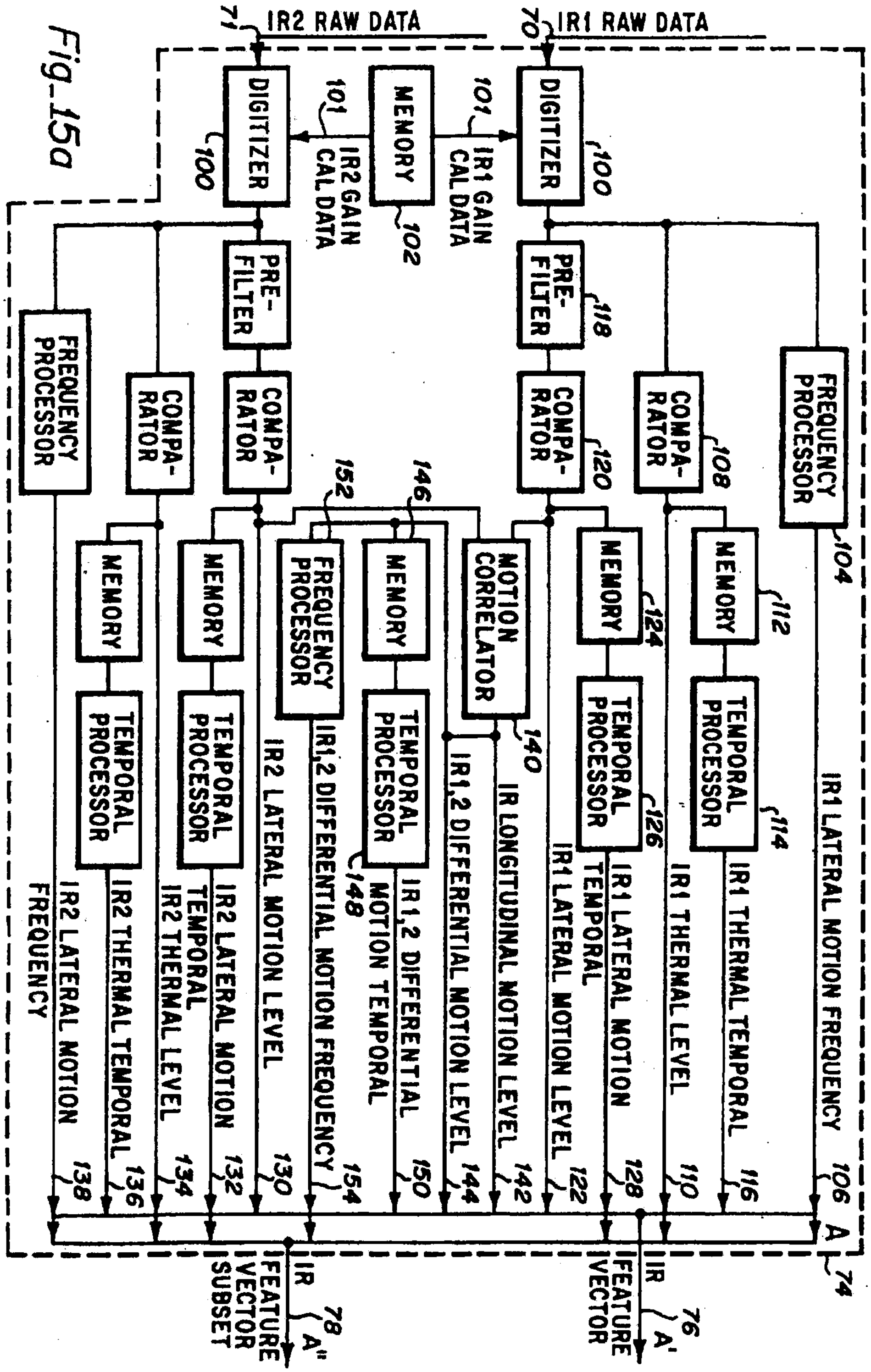

IR2 RAW DATA
IR1 RAW DATA
DIGITIZER
MEMORY
IR1 GAIN CAL DATA
IR2 GAIN CAL DATA
PRE-FILTER
COMPA-RATOR
FREQUENCY PROCESSOR
MEMORY
TEMPORAL PROCESSOR
MOTION CORRELATOR
IR1 LATERAL MOTION FREQUENCY
IR1 THERMAL TEMPORAL
IR1 THERMAL LEVEL
IR1 LATERAL MOTION TEMPORAL
IR1 LATERAL MOTION LEVEL
IR LONGITUDINAL MOTION LEVEL
IR1,2 DIFFERENTIAL MOTION LEVEL
IR1,2 DIFFERENTIAL MOTION TEMPORAL
IR1,2 DIFFERENTIAL MOTION FREQUENCY
IR2 LATERAL MOTION LEVEL
IR2 LATERAL MOTION TEMPORAL
IR2 THERMAL LEVEL
IR2 THERMAL TEMPORAL
IR2 LATERAL MOTION FREQUENCY
IR FEATURE VECTOR
IR FEATURE VECTOR SUBSET
A
A'
A"

Fig_15a

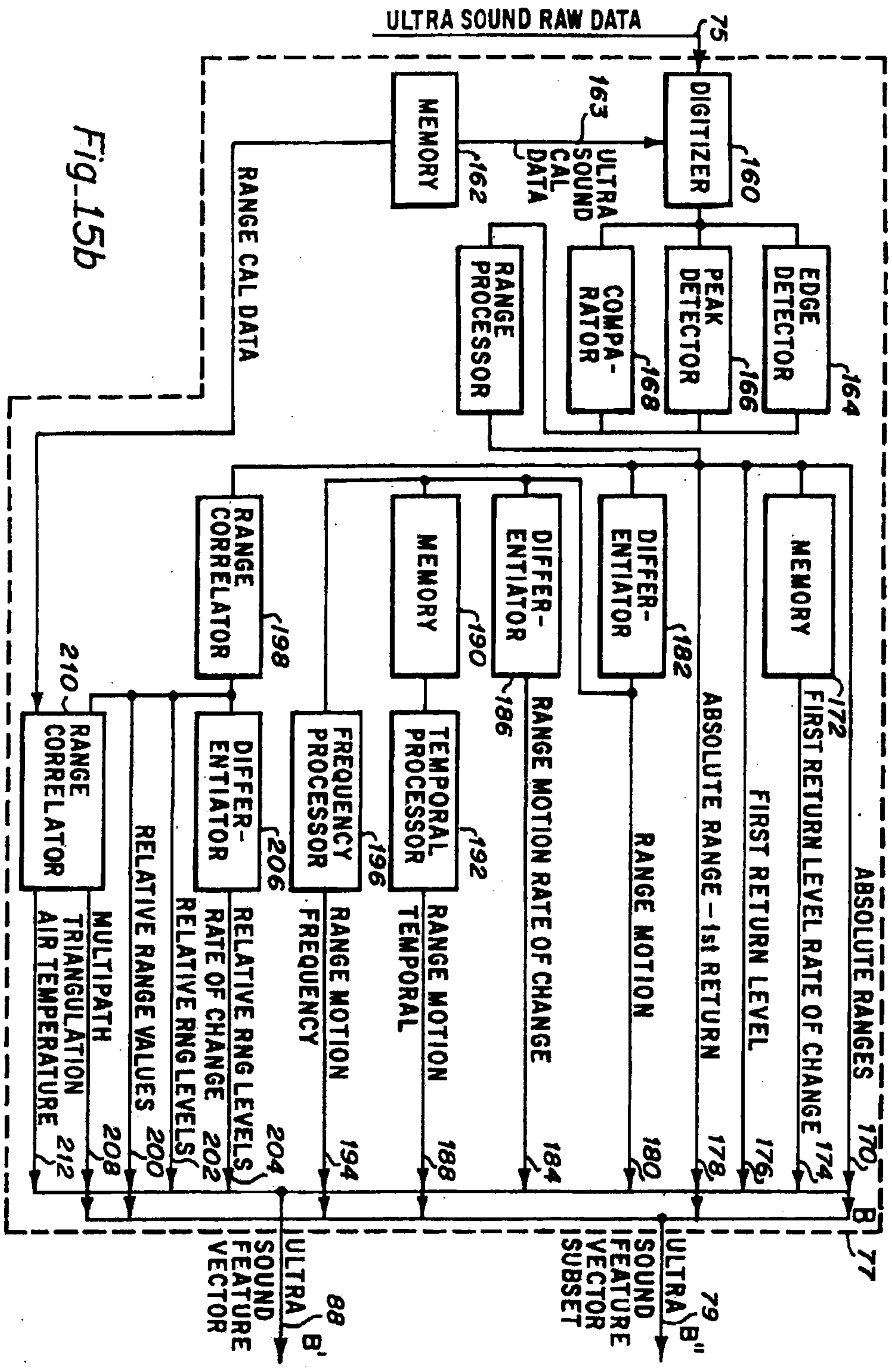

ULTRA SOUND RAW DATA
75
DIGITIZER
160
163
ULTRA SOUND CAL DATA
MEMORY
162
RANGE CAL DATA
EDGE DETECTOR
164
PEAK DETECTOR
166
COMPA-RATOR
168
RANGE PROCESSOR
MEMORY
172
DIFFER-ENTIATOR
182
DIFFER-ENTIATOR
186
MEMORY
190
RANGE CORRELATOR
198
TEMPORAL PROCESSOR
192
FREQUENCY PROCESSOR
196
DIFFER-ENTIATOR
206
RANGE CORRELATOR
210
ABSOLUTE RANGES
170
FIRST RETURN LEVEL RATE OF CHANGE
174
FIRST RETURN LEVEL
176
ABSOLUTE RANGE—1st RETURN
178
RANGE MOTION
180
RANGE MOTION RATE OF CHANGE
184
RANGE MOTION TEMPORAL
188
RANGE MOTION FREQUENCY
194
RELATIVE RNG LEVELS
204
RATE OF CHANGE RELATIVE RNG LEVELS
202
RELATIVE RANGE VALUES
200
MULTIPATH TRIANGULATION
208
AIR TEMPERATURE
212
B
77
ULTRASOUND FEATURE VECTOR SUBSET
79
B"
ULTRASOUND FEATURE VECTOR
88
B'

Fig-15b

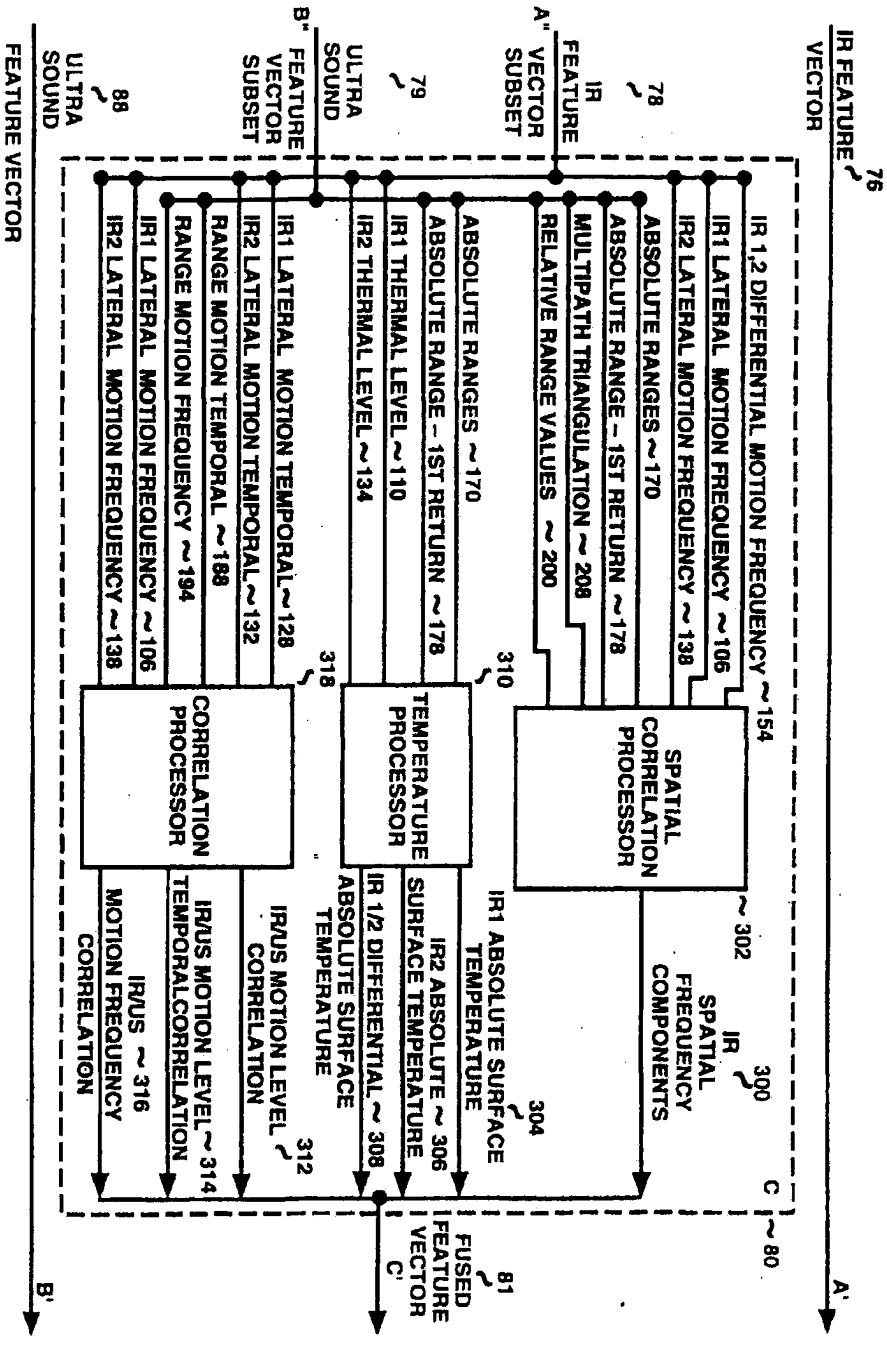

IR FEATURE VECTOR 76
A"
IR FEATURE VECTOR SUBSET 78
B"
ULTRA SOUND FEATURE VECTOR SUBSET 79
ULTRA SOUND FEATURE VECTOR 88
IR 1,2 DIFFERENTIAL MOTION FREQUENCY ~154
IR1 LATERAL MOTION FREQUENCY ~106
IR2 LATERAL MOTION FREQUENCY ~138
ABSOLUTE RANGES ~170
ABSOLUTE RANGE – 1ST RETURN ~178
MULTIPATH TRIANGULATION ~208
RELATIVE RANGE VALUES ~200
ABSOLUTE RANGES ~170
ABSOLUTE RANGE – 1ST RETURN ~178
IR1 THERMAL LEVEL ~110
IR2 THERMAL LEVEL ~134
IR1 LATERAL MOTION TEMPORAL ~128
IR2 LATERAL MOTION TEMPORAL ~132
RANGE MOTION TEMPORAL ~188
RANGE MOTION FREQUENCY ~194
IR1 LATERAL MOTION FREQUENCY ~106
IR2 LATERAL MOTION FREQUENCY ~138
SPATIAL CORRELATION PROCESSOR ~302
TEMPERATURE PROCESSOR 310
CORRELATION PROCESSOR 318
IR SPATIAL FREQUENCY COMPONENTS 300
IR1 ABSOLUTE SURFACE TEMPERATURE 304
IR2 ABSOLUTE ~306 SURFACE TEMPERATURE
IR 1/2 DIFFERENTIAL ~308 ABSOLUTE SURFACE TEMPERATURE
IR/US MOTION LEVEL CORRELATION 312
IR/US MOTION LEVEL ~314 TEMPORALCORRELATION
IR/US ~316 MOTION FREQUENCY CORRELATION
C
~80
FUSED FEATURE VECTOR 81
C'
A'
B'

Figure 16

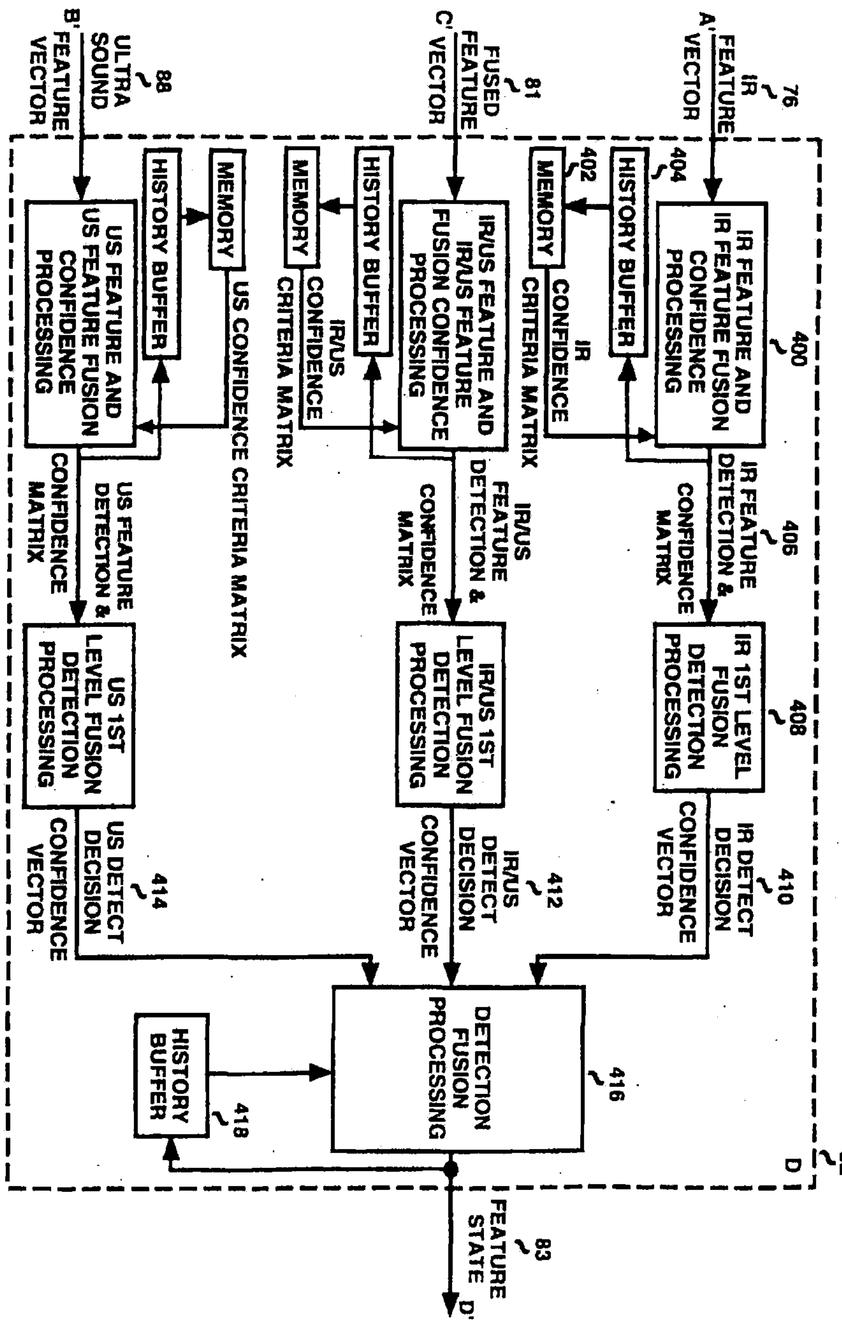

76
IR FEATURE VECTOR
A'
81
FUSED FEATURE VECTOR
C'
88
ULTRA SOUND FEATURE VECTOR
B'
400
IR FEATURE AND IR FEATURE FUSION CONFIDENCE PROCESSING
404
HISTORY BUFFER
402
MEMORY
IR CONFIDENCE CRITERIA MATRIX
IR/US FEATURE AND IR/US FEATURE FUSION CONFIDENCE PROCESSING
HISTORY BUFFER
MEMORY
IR/US CONFIDENCE CRITERIA MATRIX
US FEATURE AND US FEATURE FUSION CONFIDENCE PROCESSING
HISTORY BUFFER
MEMORY
US CONFIDENCE CRITERIA MATRIX
406
IR FEATURE DETECTION & CONFIDENCE MATRIX
IR/US FEATURE DETECTION & CONFIDENCE MATRIX
US FEATURE DETECTION & CONFIDENCE MATRIX
408
IR 1ST LEVEL FUSION DETECTION PROCESSING
IR/US 1ST LEVEL FUSION DETECTION PROCESSING
US 1ST LEVEL FUSION DETECTION PROCESSING
410
IR DETECT DECISION CONFIDENCE VECTOR
412
IR/US DETECT DECISION CONFIDENCE VECTOR
414
US DETECT DECISION CONFIDENCE VECTOR
416
DETECTION FUSION PROCESSING
418
HISTORY BUFFER
82
D
83
FEATURE STATE
D'

Figure 17

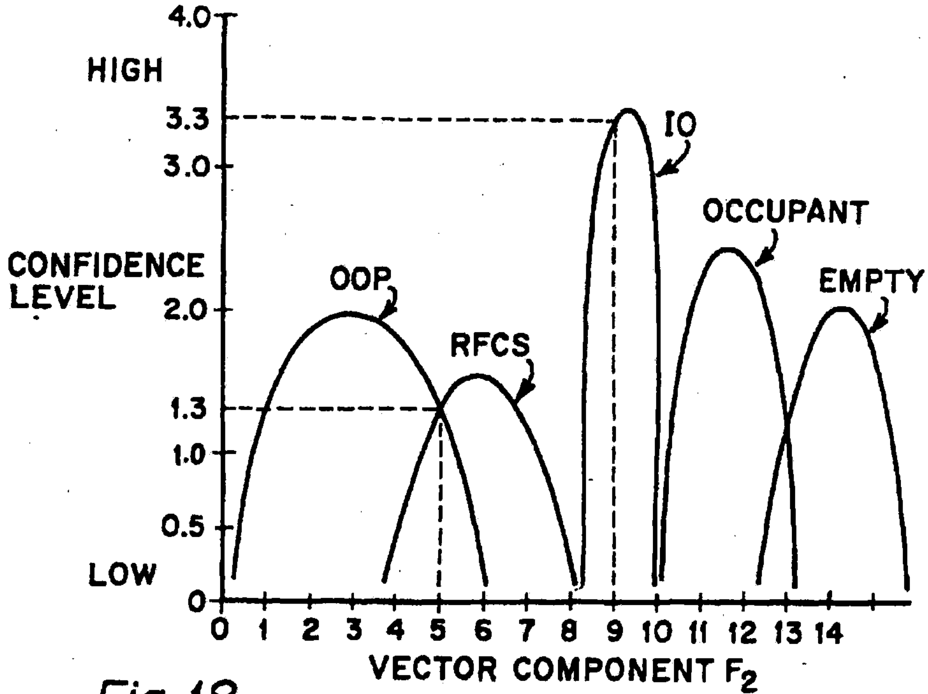


Fig_18

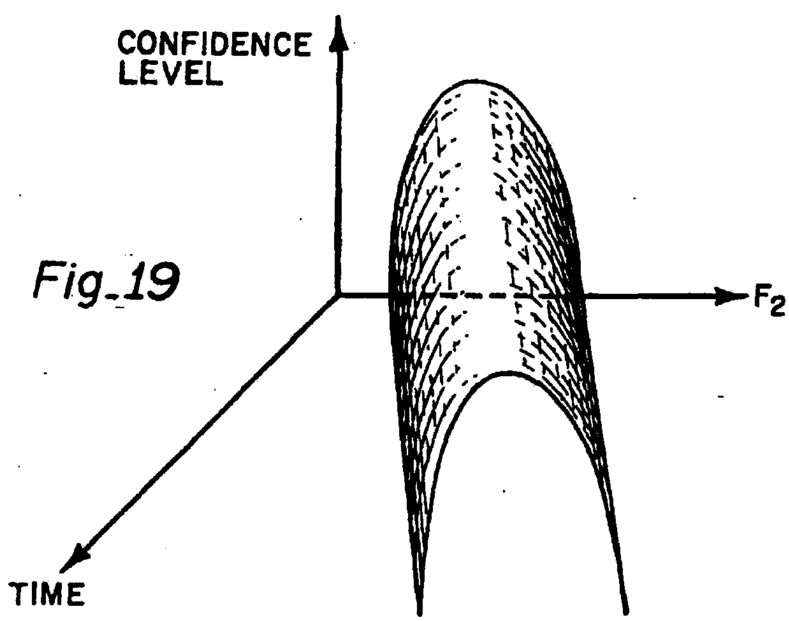


Fig_19

PROGRESSION OF CONFIDENCE LEVEL OVER TIME FOR ONE STATE OF A VECTOR COMPONENT

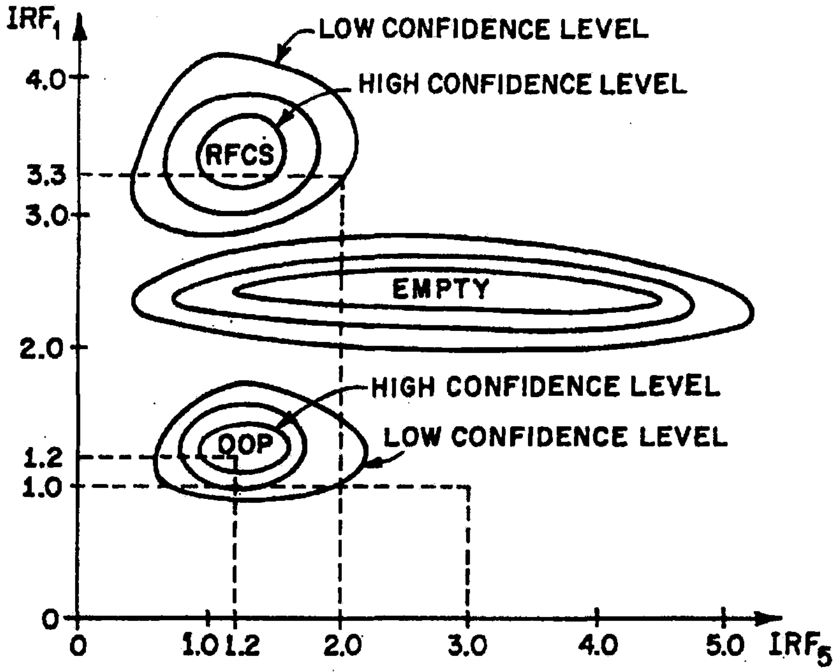


Fig_20 CONFIDENCE LEVELS FOR FEATURE VECTOR COMPONENTS

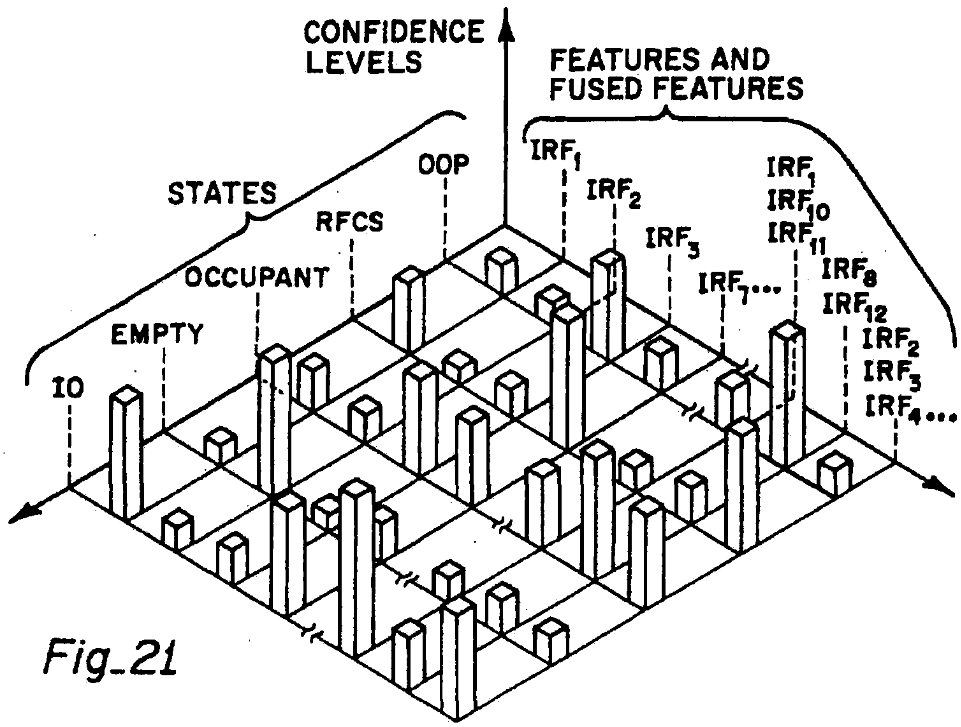


Fig_21

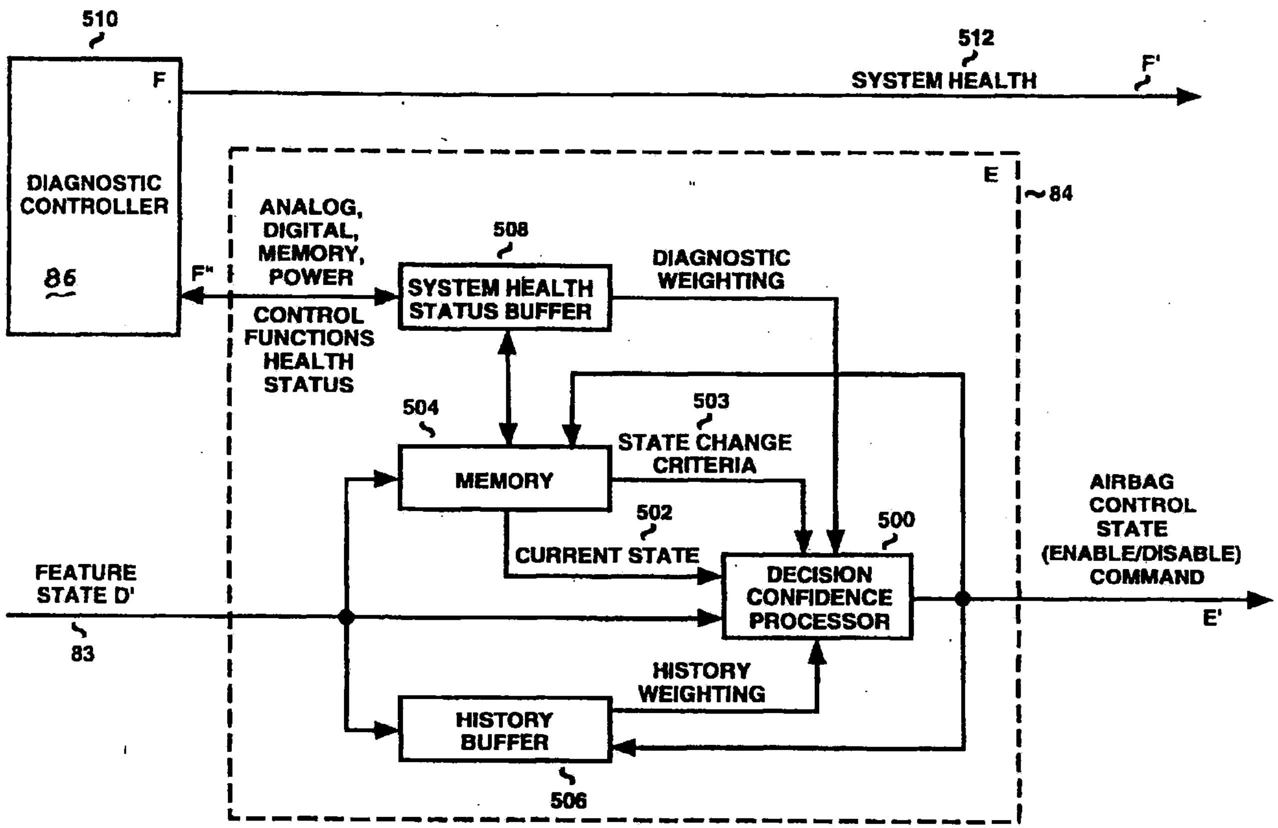
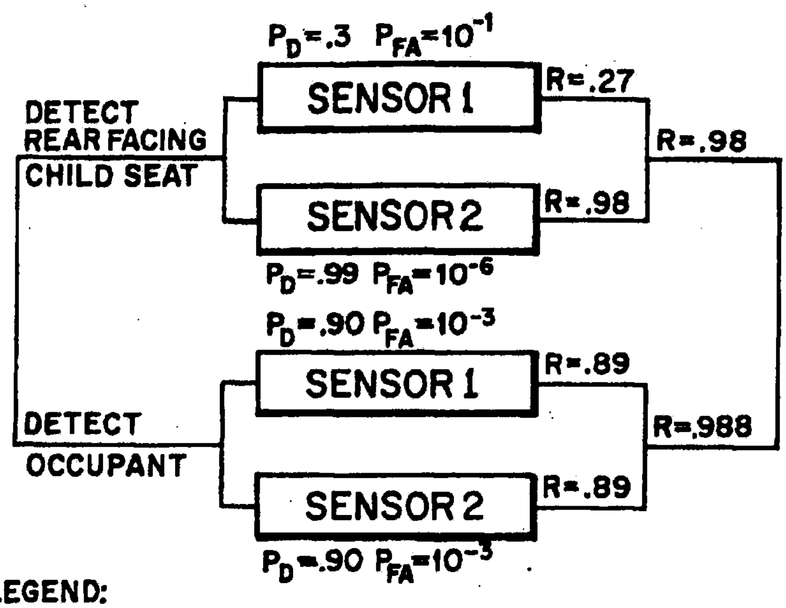

510
F
DIAGNOSTIC CONTROLLER
86
512
SYSTEM HEALTH
F'
E
~84
F"
ANALOG, DIGITAL, MEMORY, POWER
CONTROL FUNCTIONS HEALTH STATUS
508
SYSTEM HEALTH STATUS BUFFER
DIAGNOSTIC WEIGHTING
504
MEMORY
503
STATE CHANGE CRITERIA
502
CURRENT STATE
500
DECISION CONFIDENCE PROCESSOR
AIRBAG CONTROL STATE (ENABLE/DISABLE) COMMAND
E'
FEATURE STATE D'
83
HISTORY WEIGHTING
HISTORY BUFFER
506

Figure 22



LEGEND:

P_D = PROBABILITY OF CORRECT DETECTION

P_{FA} = PROBABILITY OF AN INCORRECT DETECTION (FALSE ALARM)

R = RELIABILITY, 1.00 = 100%

Fig_23

AOS Detection Condition	Range Motion	Range Abs	R Motion	R Abs	Detection Pd
RFCS	0.9959	0.9959	0.3760	0.2747	0.999992
Occupant	0.9163	0.9519	0.9959	0.7026	0.999995
Empty Seat	0.9163	0.9519	0.9959	0.7924	0.999997
RFCS under 2 Thick Blankets	0.9591	0.9742	0.1892	0.2747	0.999379
AOS Diagnostic Condition	**R Sensor**	**US Sensor**	**ASIC Circuits**	**Circuit Controller**	**Diagnostic Pd**
Blockage	0.9742	0.9959	0.0000	0.0000	0.999894
Part Failure	0.9591	0.9591	0.9742	0.9742	0.999999
Out of Spec Part	0.9163	0.9163	0.9591	0.9519	0.999986

Fig. 26

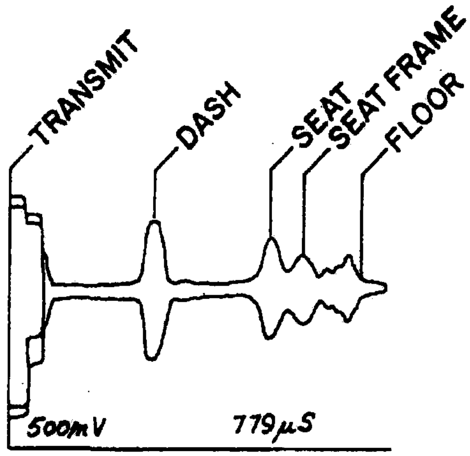


Fig_24a

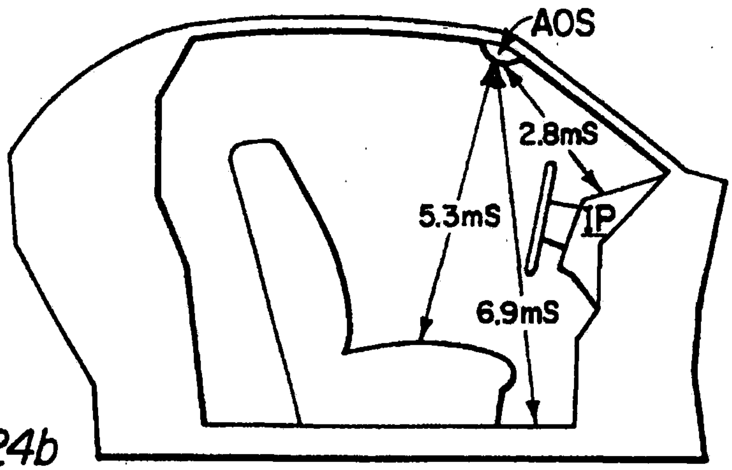


Fig_24b

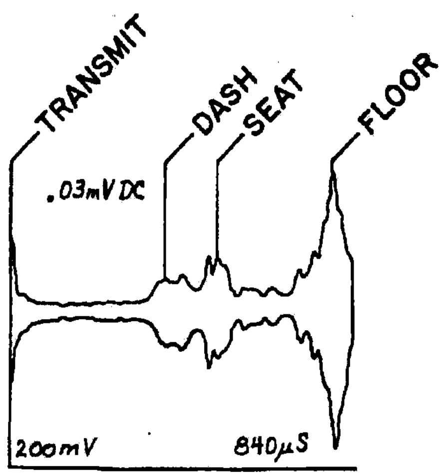


Fig_25a

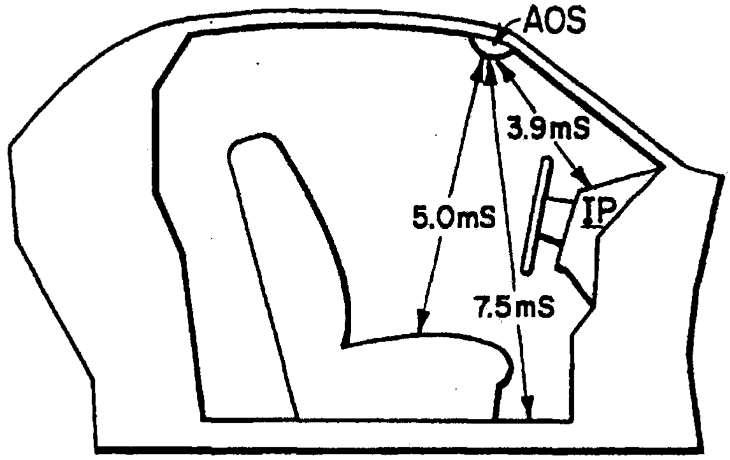
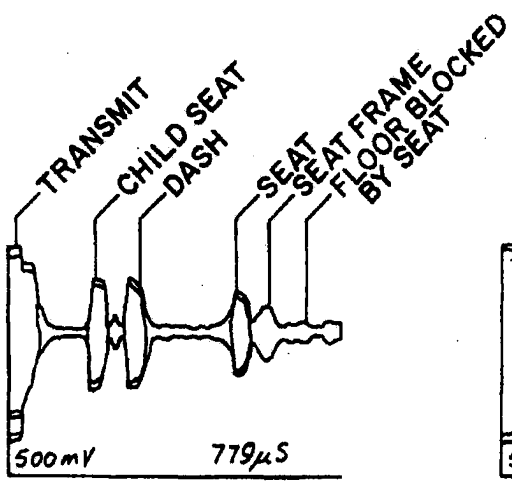
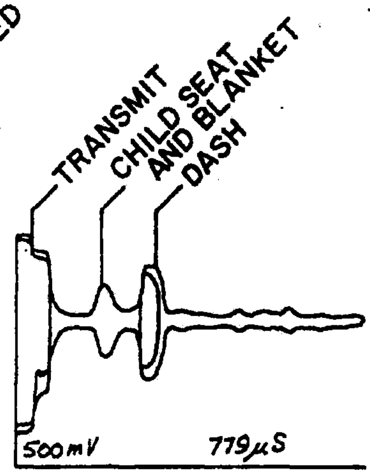


Fig_25b





VEHICLE: 93 LH
SENSOR: P-1 OVERHEAD
STATUS: RFCS

AIR TEMPERATURE: 22.6°C
SURFACE TEMPERATURE: 25°C

Fig_27a

VEHICLE: 93 LH
SENSOR: P-1 OVERHEAD MOUNT
STATUS: RFCS UNDER 2 BLANKETS

AIR TEMPERATURE: 22.6°C
SURFACE TEMPERATURE: 25°C

Fig_27b

AUTOMOTIVE OCCUPANT SENSOR SYSTEM AND METHOD OF OPERATION BY SENSOR FUSION

SPECIFICATION

1. Field

The present invention relates to sensor systems and methods of operation for use in automotive interiors to sense the presence, position and type of object in a seat and provide a condition signal for use with other automotive systems, and more particularly in conjunction with air bag activation or other type of safety restraint system for protection of passengers in the event of a collision. One embodiment of the present invention is directed to a multi-sensor occupant detection system for use in conjunction with air bag activation for determining by sensor fusion the presence or absence of a human or animal occupant, the presence and orientation of child seat (front or rear-facing), an out-of-position occupant or other types of occupancy to signal the appropriateness to deploy (or not) the air bag, thereby increasing the reliability and safety of an air bag activation system.

2. Background

Virtually all modern vehicles, autos, vans and trucks, on the American road now have air bag deployment systems. An increasing fraction of the air bag deployment systems currently available includes a passenger-side air bag as well as a driver-side air bag.

However, a passenger-side air bag deployment system presents problems in regard to criteria for deployment. That is, it is not simply an issue of always deploying a passenger air bag, as injury to occupants passengers can occur by deployment in certain situations. For example, the airbag should deploy only if a passenger is in fact occupying the passenger seat, and should not deploy when the seat is empty. However, even more importantly is the problem of deploying a passenger side air bag when there is present in the passenger seat a rear-facing child seat (RFCS), because the deployment of an air bag against the back portion of an RFCS occupied by a child can cause serious injury to the child by catapulting the child into the back of the car seat, thus defeating the safety advantages of both the air bag and the RFCS during a collision.

Accordingly, it is very important to provide a means for determining when the passenger seat is occupied and when it is not occupied. It is even more important to determine when the passenger seat is occupied by a child in a RFCS so that such information can be used to prevent deployment of the airbag when the child seat is present in that orientation. Of course, any means for determining the status of an occupant in the passenger seat, including the presence and orientation of a child seat, must be highly reliable in order to signal deployment of the air bag when the passenger seat is occupied by a passenger and prevent deployment of the air bag when the passenger seat is occupied by a child in an RFCS.

However, it is no easy task to provide a sensor system, meaning sensor units and methods of operation and signal processing, to reliably detect change of state from an empty to an occupied seat and determine the nature, position (location) and/or orientation of a passenger in the vehicle. By way of example, if a thermal sensor is used, its reliability may be reduced by thermal conditions within the vehicle which can change dramatically with the seasons, weather, vehicle interior configuration, rapidly changing exterior

shading, passenger clothing and/or size and driver's choice of interior climate, smoking, etc. Thus, a thermal sensor acting alone can lead to falsely declared occupant presence, and more importantly, failure to detect the presence of an occupant. Furthermore, there may be cases where the thermal signature of a rear-facing child seat blends so well with the seat upholstery that a thermal sensor does not see it, allowing the airbag system to deploy despite the presence of a child-occupied RFCS.

Conversely, if one were to use instead distance measurements, such as by the use of acoustic sensors, such sensor must be capable of distinguishing between the presence of an RFCS and the presence of a passenger holding an object which can result in distance measurements which mimic the presence of a rear-facing child seat.

There are other scenarios as well that require a sensor system to recognize and take appropriate action, such as a forward-facing child seat, inanimate objects, a passenger holding an inanimate object, an out-of-position passenger, and so on.

In addition to these basic sensor requirements, the system for determining the presence of a passenger in the passenger seat and the presence or absence of a rear-facing child seat, must be cost effective and must be in a sufficiently small package to prevent interference with normal vehicle operation. Such systems must be compatible with the aesthetics of the vehicle so as not to affect a vehicle's salability particularly as it relates to new passenger cars. Furthermore, the cost of installing such system in the vehicle must remain simple to keep manufacturing cost low. Preferably, all the sensors should be kept in a single unit to ease the assembly of the vehicle in production or retrofitting older vehicles.

There is no currently available sensor system known to the Applicants which can reliably distinguish the presence and absence of a passenger in the passenger seat as well as the presence or absence of a rear-facing child seat in the passenger seat.

There is also no currently available sensor system that can account for a wide variety of possible variations in both thermal and distance parameters that are encountered in the actual wide range of circumstances of occupancy, nor one that is sufficiently versatile to be adaptable to the wide range of vehicle interior configurations.

An example of a system for actuating a driver airbag restraint is shown in White et al U.S. Pat. No. 5,071,160 (Automotive Systems Laboratory) which employs an ultrasonic acoustic sensor for sensing the position of the driver, a "pyrotechnic" sensor for sensing the presence of the driver, and a pressure transducer within the seat to sense the approximate weight of the driver and an airbag control module to trigger deployment of the airbag. As best understood, when an impending crash is sensed by a crash sensor, a control module samples the sensed position of the passenger at fixed time intervals to calculate the rate of movement of the passenger relative to the various fixed motion structures of the vehicle. This rate of relative passenger movement is used to corroborate the acceleration data from the crash sensor and ensure deployment of the airbag where the passenger is at substantial risk of injury. That is, the interior passenger acceleration is apparently used to prevent false crash signals from the crash sensor. Early crash sensors may trigger airbag deployment during a minor bump in close slow moving traffic or during parking. This " is-the-passenger-being-accelerated-at-the-same-time" system is directed to correcting false signals from the crash sensor.

The patent describes the desired results but does not detail the process or circuitry to achieve these results beyond stating that the airbag control circuit uses error correction methods such as a plurality of each type of sensors (crash sensor, pyrotechnic, ultrasonic, acoustic, and pressure transducer) for each assigned monitoring task to prevent falsing. Accordingly, the control circuit is said to employ redundant sensors for each monitoring task and the instructions executed by the control module are said to include error correction subroutines known to one skilled in the art. A dashboard signal lamp can be lit when the airbag effectiveness is too low, or the likelihood of passenger injury by the airbag is greater than the injury if he hit the steering wheel, dash or knee bolster, the latter being consistent with the slow bump situation described above.

Accordingly, there is a need in the art for a reliable occupant sensor system for use in conjunction with vehicle air bag deployment systems. There is also a need for a sensor system that can meet the aforementioned requirements for reliability in detecting the presence or absence of a passenger or RFCS in a wide range of circumstances, irrespective of whether a passenger is holding an object and irrespective of the thermal conditions that may be found in the vehicle. Such a sensor system must also be a cost effective component of the vehicle that does not detract from the aesthetics of the vehicle interior or unduly increase the cost of manufacturing or assembling a vehicle.

THE INVENTION

OBJECTS

It is an object of the present invention to provide an automotive occupancy sensor system to reliably detect the presence or absence of a passenger in the passenger seat and the presence or absence of a rear-facing child seat in the passenger seat and to provide a signal to the airbag system to either inhibit or permit the deployment of a passenger side air bag during a collision.

It is another object of the invention to provide a vehicle passenger sensing system which relies upon multiple sensors utilizing different physical phenomena to provide signals which are processed by sensor fusion to significantly enhance the reliability of passenger detection while permitting the use of relatively low cost conventional sensors.

It is another object of the invention to provide a vehicle occupancy sensing system adapted for use with a passenger seat of a vehicle to control the deployment of an air bag, and specifically to inhibit the deployment of an air bag when a passenger seat is unoccupied, or occupied by inanimate objects, or the occupant is out-of-position, and when an RFCS is present in the passenger seat, in order to prevent unneeded deployment or unsafe deployment which might otherwise cause injury.

It is another object of the invention to provide a passenger occupancy sensor system which utilizes both thermal and acoustic sensors, the signals from which are processed in a fusing algorithm to produce an output signal permitting deployment of a passenger side air bag only when the passenger seat is occupied by a passenger properly positioned in the seat and inhibiting deployment of an air bag in other preselected conditions of occupancy.

It is another object of the invention to provide a multiple sensor occupancy detection system which processes by sensor fusion certain preselected features extracted from signals provided by different certain sensors which sense different physical parameters to increase the reliability of the individual sensing characteristics of the individual sensors.

It is another object of the invention to provide a multiple sensor occupancy detection system while maintaining low cost in manufacturing of the vehicle by locating sensors in a single unit to ease the task of mounting the sensor system to the vehicle.

It is another object of the present invention to provide a multiple sensor occupancy detection system while maintaining aesthetics of the vehicle by producing a sensor system of minimal size.

It is another object of the invention to provide a sensor system that can be tuned to individual vehicle interior configurations with unparalleled precision of discrimination by sensor fusion signal processing to produce state, condition or decision signals that may be used as input to a wide variety of automotive systems, including but not limited to occupant safety, vehicle integrity and safety, vehicle operating systems condition or position (e.g. seat position and load adjusting systems), unusual conditions, interior temperature control, unauthorized entry (Passive Theft Detergency), near object detection systems, and the like.

Still other objects will be evident from a review of the Summary, Drawings, Detailed Description and claims hereof.

BRIEF DESCRIPTION OF DRAWINGS:

The invention will be more fully understood hereinafter by reference to the drawings in which:

FIGS. 1–8 show various conditions illustrative of the variety and range of real conditions that must be detected and accurately discriminated-amongst by a fully-functional automotive occupant sensor system which, by way of example, is focused on a passenger seat of a vehicle, with: FIG. 1 showing the seat being occupied by a passenger; FIG. 2 showing the passenger seat unoccupied and sensed as "empty"; FIG. 3 showing a child in a rear-facing child seat ("RFCS"); FIG. 4 showing a passenger holding a bag of groceries; FIG. 5 showing a child in a forward-facing child seat ("FFCS"); FIG. 6 showing a dog in the seat; FIG. 7 showing an out-of-position passenger ("OOP"); and FIG. 8 showing a moderate sized package on the seat;

FIG. 9A is an enlarged front view of the sensor taken along line 9—9 of FIG. 2 having an infrared sensor and an ultrasound sensor contained in a single unit, and illustrating a multi-element Fresnel lens system over a dual-detector infrared sensor;

FIG. 9*b* is a longitudinal section view of the IR sensor taken along line 9B—9B of FIG. 9A;

FIG. 9C is a transverse section view of the IR sensor taken along line 9C—9C of FIG. 9A;

FIG. 10 is a view of the passenger seat and the sensor unit in relative relationship, illustrating the infrared detector zoning of the seat and seat back areas as sensed through the Fresnel lens;

FIG. 11*a* is a side view illustrating the infrared detectors fields of view coverage on the passenger seat;

FIG. 11*b* is a side view illustrating a typical ultrasound transducer field of view coverage on the passenger seat;

FIG. 12 is a schematic diagram of the electronic circuit of an embodiment of the sensor system of the present invention;

FIG. 13 is a functional block diagram of an application specific integrated chip ("ASIC") means for carrying out the sensor fusion methods of the present invention;

FIG. 14 is a signal processor functional block diagram illustrating the processing steps used in the operation of the presently preferred best mode embodiment of the sensor system of the present invention;

FIG. 15a and 15b are feature processing block diagrams showing the steps of processing raw data from the sensors to produce infrared (FIG. 15a) and ultrasound (FIG. 15b) feature vectors;

FIG. 16 is a fused feature processing block diagram illustrating the process of fusing infrared features and ultrasound features to produce a fused feature vector;

FIG. 17 is a detection processing block diagram showing the processing of the infrared feature vector, ultrasound feature vector, and fused feature vector to produce a feature state;

FIG. 18 is a graph illustrating the relationship between a feature vector component and confidence levels of various occupancy states by way of example: OOP state, RFCS state, inanimate object state, occupant'state, and empty state;

FIG. 19 is a graph illustrating the progression of confidence levels for a given state and a given feature vector component over time;

FIG. 20 is a graph showing confidence level upon fusion of two feature vector components;

FIG. 21 is a graphically illustrated matrix of the relationship between vector components, and fused vector components, states, and confidence levels; and

FIG. 22 is decision processing block diagram illustrating factors considered in a state change decision process.

FIG. 23 is a diagram of sensor decision reliability in a case of discriminating between a normal occupant and an RFCS;

FIG. 24a shows a signature trace from an automobile;

FIG. 24b shows the physical layout of the vehicle giving the trace of FIG. 24a;

FIG. 25a shows a signature trace from a truck;

FIG. 25b shows the physical layout of the vehicle giving the trace of FIG. 25a;

FIG. 26 is a table of test data from actual testing of a sensor system of the invention; and

FIGS. 27a and 27b are comparative traces showing sensibility of the discrimination between an RFCS and the same RFCS covered with two blankets.

SUMMARY

The present invention is directed to an automotive interior occupant sensor system employing sensor-fusion signal processing which combines information provided by two or more sensors, each of which "sees" the world in an unique sense. The multi-sensor fusing process of this invention greatly enhances performance and reliability in much the same way as human ability to visually distinguish and classify objects is greatly enhanced with the addition of sound. While the invention is described in detail with respect to sensing the presence (or absence) of a variety of seat occupants for the purpose of sending a signal to an airbag deployment system thus enabling or disenabling the airbag system to permit or prevent deployment in preselected situations, the "decision" or state signal produced by the sensor system apparatus and sensor signal fusion method of this invention may be applied to also, or alternately, check, affect or trigger other systems, such as automatic safety belts, seat positioning systems, interior climate controls, lighting, dashboard or other signal or warning lights, audio alert or status signals (buzzers, recordings, or synthesized voices), door locks, load adjusting systems, reminder systems crash conditions recording systems, and the like.

In a preferred embodiment, the automobile passenger seat occupancy sensor of the present invention relies on two detectable properties: One such property is the thermal signature and associated motion, and the second is the acoustic distance and the associated acoustic motion. By relying on two distinct sensors in which a plurality of independent features (or characteristics) are extracted and fusing some of these features, the accuracy and reliability of sensing is vastly improved as compared to single sensor or even multiple sensors not employing sensor fusion. For example, in cases where the thermal signature of a rear-facing child seat blends with seat upholstery and provides no motion signal, the distance measurement may be able to detect that something is in the seat with suitable reliability. However, in cases where passengers are holding objects or are much larger than normal, an ultrasonic sensor will provide ambiguous distance measurements which "look" like an RFCS. By the fusion method of this invention, combining features extracted from IR detectors angled and zoned to "look" at different fields and from an ultrasound sensor can ensure proper identification and output of an appropriate decision signal.

In accord with the present invention, measurements of conditions are taken continuously and compared to prior conditions to provide a current state profile. At least initially, the updates are compared to initial conditions obtained at the start-up of the vehicle, and later the comparison is with prior state conditions. If initial conditions indicate a recognized (or "valid") occupant, this condition will tend to prevail throughout operation of the vehicle with the sensor algorithm always erring on the side of safety. If initial conditions indicate an empty seat, a "wake up" mode ensures that passengers changing seats during vehicle operation are detected. A standby mode while ignition is off may be provided in order to draw less power and perform only the minimum required periodic checks and maintenance functions.

Individual sensors will make incorrect decisions by themselves under certain conditions but in unrelated, non-overlapping ways. The fused sensor approach of the present invention covers these failure modes to assure reliable performance by requiring analysis of many different signal features before making a recognition decision. Ordinarily, to compensate for its own area of marginal performance, an individual sensor must become more and more sophisticated, driving up costs. In contrast, the system of the present invention employs fused data from two or more inexpensive sensors, thus achieving the required sophistication level, yet at a significantly reduced cost. Further, in dual sensor operation, self-diagnosis is enhanced by correlating data in one sensor with data from the other.

Although the preferred embodiment of the present invention utilizes passive thermal and active acoustic sensing for their inherent design, simplicity, and safety features, it will be understood that the present invention is not necessarily limited to the use of multiple sensors of the particular type disclosed. While the selected sensors are non-radiative and present no electromagnetic, electro-optic exposure or other exposure hazards to the occupants, it will be understood that other combinations of two or more sensors of different types for occupancy sensing can be readily used to achieve the simplicity and yet high reliability, of the present invention by the sensor fusion method of the present invention. In any

case, the sensors disclosed herein do not present any exposure hazards to occupants; for example the ultrasonic unit operates at a frequency well above the hearing range of humans and dogs.

It should be understood that the present invention is not necessarily limited to use in conjunction with an air bag system. It can also be used for security and safety purposes because the combination of two distinct sensor characteristics such as the combination of thermal contrast and motion with acoustic distance and motion as shown herein, prove highly advantageous for its reliability and simplicity in a number of applications outside a vehicle as well as other applications with a vehicle. It may be used as a security system for the premise of a piece of property, both inside of a building as well as outside of the building.

In the preferred embodiment of the invention, infrared sensor inputs and an ultrasonic sensor input are combined in a microprocessor circuit by means of a sensor fusion algorithm to produce an output signal to the air bag controller. The signal results from preselected confidence weighting for the various parameters extracted from the two sensors (called features), and upon a fusion process which ultimately makes a decision which is extremely reliable. An empirical profile, in the form of a lookup table, matrix of values, or empirical relationships, or algorithm is provided for a plurality of known objects (e.g, human occupant, empty seat, rear and forward facing child seat, animal, packages, etc.) either as a generic interior profile or as developed (empirically determined) for a particular interior. During operation the fusion processing compares the signals to a matrix of known condition confidence values to produce a set of confidence weighted values. By way of example, some 14 selected IR features and 13 selected ultrasound features are compared either directly or after fusion to arrive at an overall confidence level that results in triggering the enable/disenable signal (or absence of signal) to the airbag deployment system. The output signals are compatible with AECM interfaces.

The IR sensor unit advantageously includes dual detection elements that look at different areas of the seat, e.g. the seat back and the seat itself. In addition, the "view" of these sensor elements are zoned into vertically oriented parallel zones by means of one or more Fresnel type lenses so that "thermal motion" features can be extracted from the change in thermal signatures from zone to zone.

The occupant sensor algorithm performs the sensor fusion matrix processing and decision making operation on the selected sensor outputs. The fusion matrix has inputs weighted to guarantee reliability in the decision making process. All sensor outputs along with empirical "known" condition data, calibration data, initial conditions and updated historical reference data are considered in the process of making a decision (outputting an enable or disenable signal) whether or not to suppress the deployment of the passenger-side air bag in a collision. By fusing the features and feature vectors to make the decision, each individual parameter has only a partial effect, or "vote", on the ultimate fusion decision. The final decision is based on several conditions or states reinforcing that decision by requiring several independent phenomena or aspects thereof to occur simultaneously.

The fusion process of the invention produces decision with a higher reliability than a single phenomena sensor or non-fused multiple sensors. In addition to performing the multi-sensor fusion decision making, the process requires periodic analysis of the sensor outputs to make certain that all sensors are functioning properly. In addition to normal electrical condition checks, conditions from each sensor output are compared with the output from the other sensor to be sure that all sensors confirm proper operation. In the unlikely scenario where the sensor system fails entirely due to power failure, component failure, or otherwise, the air bag deployment system controller defaults to deployment condition to ensure passenger safety. A diagnostic warning indicator of a failure condition may be provided to the vehicle's indicator panel.

All the sensors of the present invention can be provided in a single unit to maintain low manufacturing cost and simplify the task of assembling the sensor system to a new vehicle or retrofit it to a previously-assembled vehicle. In addition, the aesthetics of the vehicle is maintained by keeping the sensor system unit to a minimal size.

Having two or more sensors in the fusion mode enhances self-diagnostic correlation between the two, for if there is a failure of one but not the other, even in scenarios where no or little signal is expected from the failed sensor, still some of the expected features will be missing and analysis and fusion will identify the failed sensor. For example, if US indicates an occupant, the IR can be polled. If it indicates no occupant, then a potential sensor malfunction is indicated. If there are some features from the IR, say weak signal IR, then the IR may be working but it is not clear what is in the seat until other polled features are analyzed by the fusion process algorithm of the invention.

While a fixed sensor system with angled lenses (for the IR) are shown, a mechanical sweep scan can be employed by mounting one or more sensors on a moving element. Likewise while a fixed US transducer and receiver is shown using pulsing to toggle or poll the sensor, a separate transducer and receiver may be employed. The acoustic signal profile may be shaped to the interior for maximum or narrowly focused coverage in a specific area.

The IR sensor may be an uncooled electric device that responds to IR radiation from the near to far IR (2–12 micrometers wavelength), and the US may be an electrostatic type sensor with a typical frequency range of 40 KHz to 150 KHz. The typical field of view will be approximately 30°×34° for the IR, and 20° to 30° (conical direct or offset) for the US. The US is highly immune to interference because the pulse echo must be received within a preselected time window to be valid. The US beam may be asymmetric for better coverage. A separate IR sensor can be added to the unit oriented to look at the center (middle) passenger location.

Without additional hardware the system of the invention can automatically cycle "on" to measure the interior temperature of the vehicle in which it is installed and send a signal to automatically adjust or cause the cooling fan to operate whenever the interior temperature exceeds a preselected (design selected) maximum value. Additionally, the system can automatically, at "power up", measure the characteristic interior "signature" of the particular vehicle in which it is installed, and by comparing these values to predetermined reference tables imbedded in the ASIC, determine which type of platform it is installed in, e.g., auto or truck. It can then transmit the vehicle identification type to the body controller thus automatically verifying correct and proper functioning at the final installation/assembly point.

The ASIC of this invention permits several additional features to be optionally incorporated into the sensor system of this invention as desired. These include: 1) Center Passenger Occupant Detection (CPOD) employing an additional IR sensor and lens to detect center seat occupancy. 2) Four Quadrant Temperature Control (FQTC). This system

replaces presently used sun sensor and environmental control unit. It not only controls the vehicular interior temperature, but also enables automatic selection and control from one to four quadrants of directed HVAC (permitting up to four individual interior temperature settings). 3) Passive Theft Detergency (PTD). The automatic temperature control sensors can be used to detect the presence of a person in the vehicle and through communication with the body controller can decide if entry was proper or not, i.e. was a key used to gain entry (proper) or not (improper entry). 4) Near Object Detection Sensors (NODS). This system utilizes an extremely low power microwave radar which mounted behind a plastic cover (taillight or bumper), and tailored to detect objects within a preselected field-of-view.

The FQTC is similar to the occupant sensor, and uses a "multi-apertured" lens to facilitate motion detection. Further, the sensors are effectively "multiplexed" into the central network processor where sample timing, duty cycle, and sensor select sequence are all programmable.

PTD employs thermistor bolometer (TB) detectors, instead of pyro-electrics, and is thus capable of sensing both the motion of a warm object as well as being able to determine its approximate temperature. This PTD implementation is electronically configured to provide continuous or selected intermittent vehicle monitoring. The electronics (Signal Conditioner, Power Regulator, Motion Sense Logic, etc.) are configured for extremely low (less than 100 microamps) current drain on the vehicle's battery during security "system on" status, such as when the vehicle is unattended with the ignition off. This configuration permits active temperature monitoring of each zone while the automobile is in use. Further, when the vehicle is left unattended, the sensor suite is capable of detecting and reporting unwanted intrusion associated with vehicular theft or possibly a person hiding in the rear seat area.

NODS utilizes microwave (impulse) radar rather than the classical IR and Acoustic sensing, but employs sensor fusion as disclosed herein. Microwave radar is employed due to its ability to operate (invisibly) while protected from an exterior hostile environment by mounting it in a bumper or tail light assembly location. This system possesses a reliable range detection of on the order of 15+ feet. The hardware concept incorporates voltage protection, J1850 Bus interfacing and one or more ASIC(s) for control and algorithm implementation in accord with the principles of the invention. The specific frequency employed is in the range of from about 1.7 to 94 GHz.

The sensor system and methods of the invention key on the following properties: Thermal signatures or contrasts coupled with motion to establish the presence of a warm object; and Acoustic signatures via wave propagation coupled with motion to establish object status, i.e. the distance from dashboard or headliner location of occupants, objects, empty seat, etc. and if animated or stationary.

Both sensor properties are required to meet the reliability requirements because: 1) The need to inhibit the airbag when a rear-facing child seat is more reliably accomplished through dimensional measurements; these are more reliably derived from the acoustic sensor. 2) Thermal conditions within a vehicle change dramatically with seasons, weather, vehicle interior, passenger clothing, and driver use. Using an IR sensor only may lead to higher rate of falsely-declared seat status condition and, more importantly, the failure to detect an occupant present. 3) The self diagnostic capability of the system requires sensor interaction/confirmation to enhance it's reliability.

The signal processing employed in the multi-sensor fusion of this invention is preferably implemented in an Application Specific Integrated Circuit (ASIC). In addition to the signal processor ASIC, a micro-controller provides additional decision making power and system control functions. The ASIC is a mixed signal analog and digital device. It performs signal conditioning, sensor signal detection, non-volatile storage, bus interface, status signal interface, and clock generation functions. The confidence weighting and fusion matrix parameter processing is conveniently performed in software running on the micro-controller or can be implemented using hard-wired logic circuitry. The software can be implemented by one skilled in the art following the Figures as described in detail herein.

DETAILED DESCRIPTION OF THE BEST MODE

The following detailed description illustrates the invention by way of example, not by way of limitation of the principles of the invention. This description will clearly enable one skilled in the art to make and use the invention, and describes several embodiments, adaptations, variations, alternatives and uses of the invention, including what we presently believe is the best mode of carrying out the invention.

Referring now to the accompanying drawings, FIGS. 1 through 7 illustrate a variety of occupancy scenarios to which the present invention is generally directed in its preferred automotive occupancy sensing embodiment. As shown in FIG. 1, this embodiment of the invention comprises a sensor suite 1 mounted in the overhead area above and slightly to the center of the passenger seat 12 of the vehicle 14. As described in more detail below, the microprocessor controller, including an ASIC having the firmware described herein is conveniently located in the sensor unit assembly 1 mounted in the headliner 16 or dash 28. The sensor unit 1 is connected to a conventional airbag controller 2, which in turn activates an airbag 4 in an appropriate crash-sensed situation. The system is conveniently powered by the auto battery 6, or alternately by the alternator or a separate trickle-charged gell cell (not shown).

Various possible scenarios are represented by way of example in the following figures. FIG. 1 depicts the passenger seat 12 occupied by an average adult person 8, while FIG. 2 depicts an empty seat. FIG. 3 depicts the presence of a child 10 in a rear-facing child seat (RFCS) 11 mounted on the passenger seat 12. The RCFS will have an unusual thermal pattern as well as distance and vibration signatures due to the possibility that the child may in part be obscured by the seat, thus masking natural thermal radiation. FIG. 4 depicts an adult person holding a bag of groceries 18, which will also have unusual sensor readings. FIG. 5 shows the presence of a child 10 in a forward-facing child seat (FFCS) 20. Unlike the RFCS, this FFCS scenario will have a more nearly normal thermal signature for a small child as well as normal motion and distance readings. FIG. 6 shows the presence of a pet such as a dog 13. Depending on the size and activity of the pet, there will be variation in the thermal, motion, and distance readings and the rate of change thereof. FIG. 7 depicts an illustrative out-of-position (OOP) passenger scenario, where a child 10 is standing up on the passenger seat and holding onto or leaning against the dash board. It could also be a passenger adjusting the radio, or looking out of the front windshield or with his legs or feet up on the dash. In this scenario, the sensor system needs to determine the feasibility of deploying the air bag which

depends on the distance of the passenger to the location of the air bag. If the passenger is too close to the air bag location, air bag deployment may not serve any useful purpose, and indeed, might injure the occupant in the process.

It should be noted that in certain scenarios, the location of the sensors unit in the headliner is an advantage. Comparing for example, FIGS. 3 and 7, if the sensors are located at position X and/or Y as compared to the more universal, wide-angled headliner position 16, the RFCS 11 or OOP occupant 15 may obscure or overload one or more of the sensors by coming in contact with the sensor unit face.

The seat may also be occupied by passengers of different size, such as a small child or a larger person. An occupant may be reclined in the passenger seat or sleeping in the passenger seat without giving off much movement, and both cases will have unusual motion, distance, and thermal signature. Referring to FIG. 8, there may be inanimate objects 17 of various size on the seat which may or may not give off thermal and/or motion signatures.

In addition to these scenarios, the weather and shading conditions may affect the interior environment of the vehicle, especially the interior temperature of the vehicle. On a hot summer day, the passenger seat will be extremely hot after the vehicle has been sitting closed in the sun, and this condition can affect sensor readings. In addition, driving along a tree lined highway can lead to thermal flicker, which could mimic a motion signature, due to intermittent shading and exposure of the seat. The present invention is not limited to the detection of the above-discussed scenarios, as others can be detected as well.

Given this wide variety of occupant and external and internal conditions, the present invention must be able to detect, discriminate and make a decision to permit transmission of an air bag enable signal, or generate a disenable signal to the air bag controller to maximize passenger safety in the event of a collision. In the preferred embodiment of the present invention, these scenarios are categorized into one of the following five states: Empty state, Occupant state, Inanimate Object ("IO") state, Rear-Facing Child Seat ("RFCS") state, and Occupant Out-Of-Position ("OOP") state. For the detected Empty state, IO state, RFCS state, and OOP state, an air bag disenable signal will be sent or supplied to the air bag controller. For the Occupant state, an enable air bag signal will be supplied to the air bag controller or, in the event that the default condition of the air bag controller is to signal the air bag to deploy, no interrupt signal will be sent from the sensor unit to the air bag controller (or air bag). Other embodiments may include more or less states with variation in the scenarios.

The Occupant state is the state where air bag deployment will enhance the safety of a passenger in case of an accident. The Occupant state includes the scenarios of an average adult person, a small child, a child in a forward facing child seat, a passenger holding a bag of groceries, a standing child in some positions, and the like. Note that in the standing child scenario, the air bag will be deployed if the child is sufficiently far away from the air bag deployment location to allow an effective and non-injurious deployment of the air bag. The air bag will not be deployed if the child is too close to the air bag deployment location, since deployment of the air bag might injure the child by knocking it back into the seat. The same consideration applies to the OOP state, a passenger positioned too close to an air bag can be sensed to prevent an injuring deployment.

Typically, it is desirable to disenable the air bag in the RFCS state, the Empty state, the OOP state, and the IO state, e.g. by sending an interrupt signal or interrupting the deploy signal from the airbag controller. It is especially important in the RFCS scenario that the air bag is not deployed in case of an accident. A deploying air bag striking the back of a rear facing child seat could catapult the child and seat backward, possibly injuring the child in the process. In the case of an Empty state or IO state, deploying the air bag in case of an accident ordinarily does not serve any useful purpose, and only adds to the repair cost of re-installing a new air bag in the vehicle. However, the system of the invention is biased toward deployment to ensure the highest level of safety and reliability.

In the preferred embodiment of the invention, the air bag controller is designed to default to the air bag deployment condition. For the appropriate states, such as the Empty state, the IO state, the RFCS state, and the OOP state, the sensor system sends a disenable or interrupt signal to the air bag controller. The present invention is also adaptable for use with a multi-canister controlled pressure air bag deployment system where the air bag is inflated by a number of canisters to the desired pressure. With this system, instead of sending an "on" or "off" type of signal, a quantitative serial, or multiple parallel type of signal can be transmitted to the air bag controller to indicate the desired pressure, or the number of canisters to release depending on the sensed state.

In order to recognize the various scenarios and conditions, this embodiment utilizes two sensors, an infrared ("IR") sensor and an ultrasound ("US") sensor. The infrared sensor used in this embodiment is a commercially available thermistor type of infrared sensor unit, and there are preferably two or more detector elements contained within the infrared sensor unit to allow sensor detection in or from two different regions. Although pyro-electric and photovoltaic types of infrared sensors may be used as well, the thermistor type of sensor presently provides the best cost/performance ratio. In the presently preferred embodiment, the infrared detectors sense the targeted areas continuously with an interrogation period of between about 2 Hz and 10 Hz.

The ultrasound sensor used in this embodiment is a commercially available ultrasound sensor circuit package where the ultrasound frequency and pulse can be externally controlled. The sensor operates in the ultrasonic range above the hearing range of humans and animals such as dogs, and the typical frequency ranges are from 40 KHz to 150 KHz. Frequency selection is determined by requirements such as acoustic losses, range, power, cost, and transducer size. For example, air attenuation and absorption by seats and clothing are increased with frequency; however, the required sensing range here is short, and as a result, the higher end of the frequency range can be selected. The higher frequency also provides the advantage that a small transducer head (sensing element) can be used. In the presently preferred embodiment, the interrogation period varies between 2 Hz and 20 Hz during actual operation depending on the amount or quality of information needed.

FIGS. 9A–9C are enlarged views of the sensor unit of the present invention shown in place in headliner 16 of FIG. 1. The sensors may be placed separately at different locations, but in the preferred embodiment, as shown in FIG. 9A, the infrared sensor 24 and the ultrasound sensor 26 are placed next to each other in a single unit 22. The infrared sensor preferably has two or more detectors 21*a*, 21*b* separated by a vertical baffle 19 and covered by a multi-element Fresnel lens 23. Each detector 21*a* (D-1) and 21*b* (D2) view different positions of the seat, 21*a* looking at seat back area 12*b*, and

21*b* looking at seat area **12*a*** (see FIG. **10**) through, in this example two rows of Fresnel lens elements, Fla and Flb, which form a lens set Ls-1 and Ls-2 respectively. Each row in this example has six individual lens elements **50*a*, 50*b*** . . . **50*n***, which look at the corresponding zones **50*a*, 50*b*** . . . **50*n*** on the seat as seen in FIG. **10**. The fields of view of the lens row Fla overlaps the row Flb, but the individual zones **50*a*** in **50*n*** do not overlap. The baffle **19** is generally aimed at the seat belt when worn properly by the passenger, as shown by arrow Q in FIG. **9**B.

FIG. 9B is a longitudinal schematic cross section of the IR sensor **24** along line 9B—9B in FIG. **9**A showing its orientation with respect to the horizontal in the headliner **16**. While the angle θ can be 0° it preferably ranges from about 5°–45° with 10°–30° being preferred. FIG. **9**C is a transverse section view of IR **24** taken along line 9C—9C of FIG. 9A. It shows the generally faceted orientation of the zones of Fresnel lens elements **50*a*** . . . **50*b***. In the alternative, the elements may be stepped with respect to each other.

The Fresnel lens allows the signal strength of a signal source from the middle of the zones to fully pass through. However, as the signal source moves toward the edges of the zones, the Fresnel lens proportionally reduces the strength of the signal passing through.

Although these sensor units can be placed in a number of places in the vehicle, it is preferred to be placed in the headliner **16** above the passenger seat as seen in FIG. **1**. The sensor unit can also be placed on the dash board directly in front of the passenger seat or on the passenger side A-pillar. It is anticipated that in the future rear passenger seats may be equipped with air bag protection as well. In this case, a sensor unit placed forward and above the targeted passenger seat in the headliner or in the B pillar can be used to sense rear seat occupancy.

FIG. **10** is a top view of the passenger seat **12** and the sensor unit **1**. The passenger seat has a back area **12*b*** and a seat area **12*a***. Each area (back and seat) is sensed in multiple zones **50*a*, 50*b*** . . . **50*n*** created by the Fresnel lens elements of the infrared sensor as shown in FIGS. 9A–9C. Note that the infrared sensor uses a Fresnel lens of the type in which each of the infrared detector field of view is divided into, for example, five to eight zones. The infrared detector converts photons (heat) into a change in conductance of the detector which results in a sinusoidal wave voltage when an object laterally crosses each zone.

FIG. **11*a*** illustrates a side view of the orientation of the two detectors **21*a*, 21*b*** (FIG. **9**) of the infrared sensor, looking at the passenger seat **12**. One detector **21*b*** is oriented to view the seating area **12*a*** while the other detector **21*a*** views the back **12*b*** of the seat. In addition to receiving zoned thermal signature data, each infrared detector senses lateral motion of the occupant or object crossing the zones **50*a*** . . . **50*n*** in its designated area **12*a*** or **12*b*** of the passenger seat. By combining data from the two infrared detectors, "longitudinal" motion of the passenger can be determined as well. By "longitudinal" motion is meant motion by a passenger (e.g. a passenger's hand) that crosses from the area detected by one detector to the area detected by the other detector, and includes both fore/aft or front/back (with respect to the vehicle) motion and vertical or up/down motion, or compound motion having both fore/aft and vertical components. FIG. **11*b*** depicts the area scanned by the ultrasound sensor **26** when aimed at the seat, and portions of the floor and dash **28**.

Referring now to the hardware aspects, FIG. **12** illustrates a circuit schematic for the preferred embodiment of the present invention. An application specific integrated circuit ("ASIC"), **30**, is designed to receive data from the infrared detector assembly **24** (S1) and the ultrasound detector **26** (S2). The ASIC processes the data by controlling a commercially available microprocessor **32**, and produces outputs to the Inhibit line at pin **28**, the vehicle on-board computer system data bus, J1850, at pin **27**, and the Diagnostic line at pin **26**. The ASIC controls ultrasound transmission by modulating an "on" or "off" voltage through pin **20** of the ASIC to the transistor, **34**. The transistor in turn is turned on for a short time period to allow current to flow through the primary winding of the transformer T1, which creates a current flow through the secondary winding of the transformer. The current flows to the transducer **27**, which in turn transmits an ultrasonic pulse. The returning ultrasonic signals are received by the transducer **27** and returned to pin **19** of the ASIC. Infrared signals from the two IR detectors **21*a*, 21*b*** (FIG. **9**) of unit **24** (S1) are received through pins **22** and **21** of the ASIC.

The incoming signals are amplified and filtered via capacitors, C5 and C6. The ASIC embodies an algorithm in its hardware and software in memory to process the signals and uses a commercially available micro-controller, **32**, to do the calculations. The resulting output is transmitted via the inhibit line to the air bag controller, The ASIC also provides a diagnostic signal regarding the integrity of the sensor system through pin **26** of the ASIC to the air bag controller (ABC **2** FIG. **1**) and the vehicle's indicator panel **28** (FIG. **1**). In the event of a system failure, the air bag controller defaults to the air bag enable state. The ASIC may receive inputs from the vehicle's on-board computer system **3** (FIG. **1**) through the J1850 data bus, the J1850, regarding the various system conditions and environmental conditions which may allow the sensor system to consider certain environmental factors and vehicle conditions in its overall calculations. The ASIC can also transmit to the vehicle's standard on-board computer its status or output. The ASIC provides an oscillating clock signal to the rest of the board through pin **16**.

The ASIC functional description is illustrated in FIG. **13**. Although the preferred embodiment is to have one ASIC chip, the described functions may be contained in two or more ASIC chips. The ASIC contains a J1850 Bus Interface **40**, Analog Outputs **42**, a Non-Volatile RAM **44**, a Digital I/O RAM **46**, a Clock Generator & Precision Oscillator **48**, and a Timing & Control subsystem **49**. The Digital I/O RAM **46** provides AGC (automatic gain control) **51** and BIAS to AC Gain **53*a*, 53*b*** and DC Gain **54*a*, 54*b*** in the processing of infrared signals, and Ultrasound Control to an Ultrasound Transmit Control **56** in the control of ultrasound through pin **20**. The Timing & Control subsystem **49** harmonizes the processing of data among an IR Feature Processor & FIFO **57**, a US Feature Processor & FIFO **58**, a US Detection **59**, a US Xmit Control **56**, and the Digital I/O Ram **46**.

There are two infrared inputs and they are processed in the same manner. The DC Gain **54*a*, 54*b*** detects and accumulates infrared signals to allow level detection by the Level Detector **60*a*, 60*b***. The fluctuating portion of the infrared signal is sent to the AC Gain **53*a*, 53*b*** for motion detection and sent to the Motion Detector **61*a*, 61*b***. The Level Detector **60** determines the amplitude and sends the information to the IR Feature Processor & FIFO **57**. The AC Gain block **53** filters the fluctuating signal with the assistance of a capacitor (C5 or C6) and sends the data to a Motion Detector **61**, which sends the processed data to the IR Feature Processor

& FIFO 57. The IR Feature Processor & FIFO produces IR Features 62.

The ultrasound signal is received through pin 19, amplified and filtered by a Gain & Filter 63, and sent to the US Detector 59. The magnitude 64 and range 65 is extracted from the ultrasound data and sent to the US Feature Processor & FIFO 58, which produces US Features 67. Both the IR Features 62 and US Features 67 are sent to the Feature Combination Processor 66 to produce Fused Features 68.

The IR Features 62, US Features 67, and Fused Features 68 are sent to the Digital I/O Ram block 46 for processing. The Digital I/O Ram 46 accesses a micro-controller through pins 2 through 14 of the ASIC (FIG. 12) to do the necessary calculations to process the data, and it accesses the Non-Volatile Ram 44 for information. The results are sent out via the Bus Interface 40 and the Analog Outputs 42.

In operation, the detection process is generally as follows: Incoming IR and US signals in a given interrogation time-period are analyzed for features (or characteristics) such as motion, frequency of motion, level of motion, temperature level, distance of objects, increasing or decreasing trends, and so on. There is a set of features for the infrared signals and a set of features for the ultrasound signal. Certain features from each set are combined ("fused") to produce a third set of fused features. Each of the three sets, or vectors, are compared to a predetermine matrix of confidence levels and empirical relationships to determine a just-sensed feature state. A feature state is one of the five possible states described above and is the state determined by the sensor system for this interrogation period. The just-sensed feature state is compared to the current state. The current state is one of the five states discussed above, and is what the sensor system indicates is the actual (near present) condition of the passenger seat. If the just-sensed feature state and the current state are different, a set of criteria is used to determine if the feature state should become the current state. The current state determines whether a disenable or interrupt signal should or should not be sent to the air bag controller.

Confidence levels, or the confidence criteria matrix, are determined as follows: Confidence levels are data obtained from analytical and empirical studies of predetermined known possible passenger seat scenarios. Each such scenario is enacted in the passenger seat under a variety of conditions, and features are obtained and analyzed, Some of the features are fused to obtain fused features. Generally, a confidence level is assigned to each feature and state combination. For example, in the presently preferred embodiment, five confidence levels are used for most features. Some of the features are not good indicators of some of the states for certain scenarios so these particular features have reduced or zero confidence levels for those states.

In more detail, from each scenario, there is a set of infrared features and ultrasound features (or appropriate readings from additional sensors, or from other types of sensors, if used). These features from each scenario are compared to features from other scenarios. After examining all of these scenarios and their features, values are assigned to each feature for each state. These values are called confidence levels, and they are assigned according to the feature's strength in indicating the particular state. For example, in the case of a thermal level (quantitative amount) feature from the infrared sensor, five confidence levels from 1 to 5, with 1 being low confidence and 5 being high confidence, may be conveniently assigned this feature's possible values. After examining thermal level features from all the scenarios, the following observations are made: A thermal level of 1 (low thermal level) is a strong indicator of both the IO state and Empty state; at the same time it is a medium indicator of both the OOP state and RFCS state, and a weak indicator of the Occupant state. A thermal level of 3 (medium thermal level) would perhaps be a high indicator of the RFCS state and OOP state, a medium indicator of the Occupant state, and a weak indicator of the IO state and Empty state; A thermal level of 5 (high thermal level) would be a high indicator of the Occupant state, a medium indicator of the OOP state and RFCS state, and a weak indicator of the Empty state and the IO state. After examining this feature, confidence levels are assigned according to the strength of the indicators for each of the states. Through this process, all of the features are assigned confidence levels. Note that some of the features may be combined ("fused") to provide additional information about the scenarios and confidence levels are assigned to the fused features as well.

Conceptually, these confidence levels are placed in a two dimensional matrix with rows and columns, the columns being the features or fused features and the rows being the states. This matrix is referred-to as the confidence criteria matrix.

In examining all the features and scenarios, empirical relationships can be deduced between the confidence levels developed from the feature and state combinations, and sets of empirical formulas can be derived to convert the confidence levels to probability values for each of the states. More specifically, in the empirical studies all the related features are gathered and analyzed for that state. The inter-relationship(s) of the confidence levels for the features are analyzed to determine how they are related in order to produce a high probability value for a particular state. From this examination, the empirical formulas are determined for this state. Then, using this set of empirically-derived formulas in actual (real-time) scenarios, a probability value (or confidence level) is obtained for the state. A set of formulas is derived for each of the states. A confidence criteria matrix and sets of empirical formulas are developed for each model of vehicle because of the variations in the interior area and passenger seat configuration for each of the vehicles.

In FIG. 14, a signal processing functional block diagram for the preferred embodiment of the present invention is illustrated. Infrared raw data from each of the detectors 21*a*, 21*b* (FIG. 9) from the Infrared Sensor 24 (IR 1 Raw Data 70 and IR 2 Raw Data 71) are processed through Infrared Feature Processing 74, which produces an Infrared Feature Vector (A') 76. Similarly, Ultrasound Raw Data 75 from the Ultrasound Transducer 26 are processed through Ultrasound Feature Processing 77, which produces an Ultrasound Feature Vector (B') 88. The ultrasound Transducer can also transmit an ultrasonic pulse via the Ultrasound Transmit Pulse Timing & Control 87. A subset of the Infrared Feature Vector (A") 78 and a subset of the Ultrasound Feature Vector (B") 79 are processed through Fused Feature Processing 80, which produces a Fused Feature Vector (C') 81. These three vectors, Infrared Feature Vector, Ultrasound Feature Vector, and Fused Feature Vector are processed by Detection Processing 82, which produces a Feature State (D') 83. The Feature State is processed by Decision Processing 84 with inputs F" from a Diagnostic Controller 86, and the Feature State is evaluated to determine a Current State (E') 85. Depending on the Current State, a signal disenabling the air bag may be sent to the air bag controller as shown. The Diagnostic Controller 86 also indicates via F^1 system health of the sensor system e.g. ok or malfunction, and in the latter case the air bag is enabled.

Sets of features are extracted from the signals for the given interrogation period. In FIG. 15*a*, the Infrared Feature Processor **74**, raw infrared data is digitized by a Digitizer **100** with reference to Gain Calibration Data **101** obtained at the start-up of the vehicle and stored in Memory **102**. Gain Calibration Data is used to calibrate sensor readings. From this digitized raw data, the frequency of the lateral motion of object or objects in the passenger seat is extracted and is calculated by a Frequency Processor **104** to obtain an IR **1** Lateral Motion Frequency component **106**. From the same digitized raw data, the thermal level of the object at the passenger seat is converted to one of the predetermined levels by a Comparator **108** to obtain an Infrared **1** Thermal Level component **110**. The predetermined levels are levels that correspondingly group analog signal values to a set of discrete n-equal levels. This component is compared against previously obtained thermal levels stored in Memory **112** by a Temporal Processor **114** to determine the trend of the thermal level (increasing or decreasing thermal level), and produces an Infrared **1** Thermal Temporal component **116**. The digitized raw data is also filtered by a Pre-Filter **118** to enhance motion property of the data, and the data is compared to predetermined levels of motion by using a Comparator **120** and an Infrared Lateral Motion Level component **122** is determined. This component is compared by a Temporal Processor **126** against previously obtained motion levels stored in Memory **124** to determine the trend of the motion level, an Infrared Lateral Motion Temporal component **128**.

Raw data from the second detector is processed in the same manner to obtain an IR **2** Lateral Motion Level component **130**, an IR **2** Lateral Motion Temporal component **132**, an IR **2** Thermal Level component **134**, an IR **2** Thermal Temporal component **136**, and an IR **2** Lateral Motion Frequency component **138**.

The motion levels from the two infrared detectors are correlated by a Motion Correlator **140** to determine a Longitudinal Motion Level component **142**, which shows any longitudinal motion of the occupant. The longitudinal information obtained from each detector is contrasted against each other to obtain an Infrared Differential Longitudinal Motion Level component **144**, which is significant when there is motion from one detector but not from the other detector. This component is compared by a Temporal Processor **148** against previously obtained components stored in Memory **146** to determine the trend of the motion level or an Infrared Differential Motion Temporal component **150**. The frequency of the longitudinal motion of the occupant is calculated by a Frequency Processor **152** to obtain an Infrared Differential Motion Frequency component **154**. The Infrared Feature Vector (A') **76** is comprised of the above described infrared components, while only features **106**, **110**, **128**, **154**, **132**, **134** and **138** are used to form the IR Feature Vector subset A", **78**.

Now referring to FIG. 15*b*, which illustrate the Ultrasound Feature Processor **77**, when an ultrasound pulse is transmitted to the targeted area, the ultrasound transducer may receive several ultrasonic returns shortly after the pulse bounces off several objects. These returns are digitized by a Digitizer **160** with reference to Ultrasound Calibration Data **163** obtained at the start-up of the vehicle and stored in Memory **162**. Each of these returns will have a point in time when the return first begins, called an edge, which is detected by an Edge Detector **164**. And each of the returns will have a point in time when its amplitude is at the highest level (or peak level) and this point in time is detected by a Peak Detector **166**. The amplitude is compared to predetermined levels by a Comparator **168** to obtain return levels. From the edge and peak level time of the returns, Absolute Ranges **170** (or distances) of the objects from the sensor unit are determined. The first return from the transmitted pulse usually indicates the object of interest in the passenger seat area and is the First Return Level component **176**. The trend (increasing or decreasing) of the First Return Level component is the First Return Level Rate of Change component **174**, which is determined with reference to previous return levels stored in Memory **172**. The Absolute Range—First Return component **178** is the absolute distance of the first object from the sensor. The rate of movement of all the returns from one pulse is the Range Motion component **180** found by using a Differentiator **182**, and the rate of movement of the Range Motion component is the Range Motion Rate of Change component **184** found by using a Differentiator **186**. Range Motion shows the radial component of motion and vibration of an object. The trend of Range Motion, faster or slower over time, is the Range Motion Temporal component **188** determined with reference to previous range motion values stored in Memory **190** and by using a Temporal Processor **192**. The frequency of Range Motion is the Range Motion Frequency component **194** determined by a Frequency Processor **196**. The relative values between the returns are determined by a Range Correlator **198** to find Relative Range Values components **200**, the corresponding levels or the Relative Range Levels components **202**, and the trend of Relative Range Levels or the Relative Range Levels Rate of Change component **204**, which is determined by a Differentiator **206**.

The relative range level components tend to indicate how objects change in relation to each other and may indicate movement of the object in interest. The range motion components indicate whether there is a constant frequency of movement which would tend to indicate an inanimate object, e.g. a vibration or flutter, or if there are random movements which would tend to indicate an occupant.

The Multipath Triangulation component **208** is where the ultrasonic pulse bounces off several objects before it is received by the transducer, and this value is compared by the Range Correlator **210** to the Range Calibration Data **162** obtained at the start-up of the vehicle. This component is helpful in determining whether there is clarity in the scene being scanned. If this component's value is low, it tends to indicate clarity in the scene and a corresponding high confidence in the scan. If this component's value is high, it tends to indicate confusion in the scene and a corresponding low confidence in the scan. The Air Temperature **212** is obtained from the fact that the air is denser at lower temperature than higher temperature, and there is a faster rate of return of the signal at lower temperature because it transmits through denser air. The Ultrasound Feature Vector (B') **88** is comprised of all of the above described ultrasound components, while the ultrasound feature vector subset comprises features **170**, **178**, **188**, **194**, **200** and **208** only.

Now, referring to block C in FIG. **16**, the Fused Feature Processing **80**, a subset of the Infrared Feature Vector (A") **78** comprises the IR **1**,**2** Differential Motion Frequency component **144**, the IR **1** Lateral Motion Frequency component **106**, the IR **2** Lateral Motion Frequency component **138**, the IR **1** Thermal Level component **110**, the IR **2** Thermal Level component **134**, the IR **1** Lateral Motion Temporal component **128**, and the IR **2** Lateral Motion Temporal component **132**. A subset of the Ultrasound Feature Vectors (B") **79** for this embodiment comprise the Absolute Ranges components **170**, the Absolute Range—1st Return component **178**, the Multipath Triangulation com-

ponent **208**, the Relative Range Values components **200**, the Range Motion Temporal component **128**, and the Range Motion Frequency component **194**. The two subsets are used to extract fused features components for the Fused Feature Vector (C') **81**. Infrared Spatial Frequency Components **300** are sets of distance, frequency, and levels of the objects calculated by the Spatial Correlation Processor **302**, which determines the distance, frequency of movement, and size of the objects detected by the two sensors. The IR **1** Absolute Surface Temperature component **304**, the IR **2** Absolute Surface Temperature component **306**, and the IR Differential Absolute Surface Temperature component **308** are, respectively, temperatures and the difference in temperature found by using the Temperature Processor **310**. The Infrared/Ultrasound Motion Level Correlation component **312**, the Infrared/Ultrasound Motion Level Temporal Correlation component **314**, and the Infrared/Ultrasound Frequency Correlation component **316** are levels of movement, the trend of the movement (slower or faster), and the frequency of movement as determined by the Correlation Processor block **318**. Note, all components of the Fused Feature Vector (C') **81** are calculated by fusing features from both the infrared and ultrasound sensors.

Now referring to FIG. **17**, depicting the Detection Processor **82**, each of the vectors is processed by its own respective feature confidence processor and confidence criteria matrix. The feature components are processed individually and some of the feature components are fused for processing. Referring first to Infrared Feature Vector processing, the components, individual or fused, of the Infrared Feature Vector (A') **76** are processed by an Infrared Feature And Infrared Feature Fusion confidence Processor **400**. In processing the components, references are made to an Infrared Confidence Criteria Matrix stored in Memory **402**, which is modified by previously processed data stored in a History Buffer **404**. This process produces an Infrared Feature Detection and Confidence Matrix **406**, which is processed by an Infrared **1**st Level Fusion Detection Processor **408** to produce an Infrared Detect Decision Confidence Vector **410**. The Infrared/Ultrasound Detect Decision Confidence Vector **412** and the Ultrasound Detect Decision Confidence Vector **414** are produced in the same manner with their respective processing blocks, history buffers, and memory.

The Detection Fusion Processor **416**, with reference to previously processed data stored in its History Buffer **418** and by using empirical formulas and relationships between and among the three detect decision confidence vectors (described above), produces a Feature State (D') **83**. A Feature State is one of the states previously mentioned: Occupant state, Empty state, RFCS state, OOP state, and IO state.

The three vectors, Infrared Feature Vector (A') **76**, Ultrasound Feature Vector (B') **88**, and Fused Feature Vector (C') **81**, are used to produce a Feature State (D') **83** as follows: Using the Infrared Feature Vector as an example, let Infrared Feature Vector={IRF1, IRF2, IRF3, . . . , IRF14}, where each of the IRF#represents a component, and where the Infrared Feature Vector has fourteen vector components (as shown in FIG. **18**). In processing the components of the Infrared Feature Vector, the confidence processor (e.g. Infrared Feature and Infrared Feature Fusion Confidence Processor **400**) refers to a confidence criteria matrix (e.g. Infrared Confidence Criteria Matrix **402**), which is data empirically developed through testing under various conditions and scenarios, as described above. The confidence criteria matrix contains the confidence levels, which may be and are usually modified by previously processed data. The confidence levels indicate the likelihood of the states for the given feature component values. For each pertinent feature component or fused feature component, there is a set of confidence levels for each state.

For example, referring now to FIG. **18**, for a particular Infrared Feature Vector Component ("IRFi") and states, an IRFi component value of 5 has an associated confidence level of 1.3 for the RFCS state, a confidence level of 1.3 for the OOP state, and confidence level of 0 for other states. For an IRFi value of 9, it has a confidence level of 3.3 for the IO state and 0 for other states. The confidence levels may be modified by previously processed vectors stored in the History Buffer, and may be modified to account for environmental and other changes. For example, should recent history show that the vehicle interior has changing thermal characteristics, e.g. starting the vehicle in cold weather with heater on full blast and later maintaining a consistent and warm temperature, the confidence criteria matrix is adjusted to account for this change. Since there is an overall higher thermal level in the vehicle, a higher thermal level is required to indicate the presence of occupants or their movement. Thus, over time, the confidence level for each of the states may vary. FIG. **19** shows a plot of the confidence level for one state of a particular vector component changing over time.

There are also fused features confidence levels, where two or more vector components can indicate confidence levels for the states. For example, in referring to FIG. **20**, an IRF5 value of 1.2 and an IRF1 value of 1.2 would result in a high confidence value for the OOP state and 0 for other states; an IRF5 value of 3 and an IRF1 value of 1 will have a confidence level of 0 for all the states; and an IRF5 value of 2 and an IRF1 value of 3.3 will have a low confidence value for the RFCS state and 0 for other states. For each feature vector, there are a number of these possible fused vector components and their associated confidence levels. The output of the feature and fused feature processing block is a matrix, called the detection and confidence matrix (e.g. Infrared Feature Detection and Confidence Matrix), shown graphically in FIG. **21**. Note that a fused vector may fuse two or more feature vector components.

The Infrared Feature Detection and Confidence Matrix **406** (FIG. **17**) is input to the Infrared **1**st Level Fusion Detection Processor **408**. In the previous step, confidence level calculations provide each individual Infrared feature or fused features with its own detection 'decision'. These individual decisions are now factored together by state in empirically derived functional relationships and formulas, as described above, i.e.:

IR confidence (RFCS)=Function of {IRF1(RFCS), IRF2(RFCS), . . . IRFn(RFCS), IRF3,4,5(RFCS), IRF1,10,11 (RFCS), IRF8,12(RFCS), . . . };

IR confidence (Occupied)=Function of {IRF1(Occupied), IRF2 (Occupied), . . . , IRF8,12 (Occupied), . . . };

IR confidence (OOP)=Function of {IRF1(OOP), IRF2 (OOP), . . . , IRF9,11 (OOP), . . . };

IR confidence (IA)=Function of {IRF1(IA), IRF2 (IA), . . . , IRF8,12 (IA), . . . }; and

IR confidence (Empty)=Function of {IRF1(Empty), IRF2 (Empty), . . . , IRF9,11 (Empty), . . . }.

Each of the above functional relationship will produce a value which indicates the confidence level (or probability value) for the associated state. The output of this process is a vector, called detect decision confidence vector (e.g. Infrared Detection Decisions Confidence Vector **410** in FIG.

17), where each state has an associated confidence value. An example of the Detect Decision Confidence Vector is: Infrared Detection Decision Confidence Vector ={OOP state: 0.02, Empty state: 0.90, RFCS state: 0.04, IO state: 0.0, Occupant state: 0.20}. In the same fashion, the Ultrasound Detect Decision Confidence Vector **414** is produced from the Ultrasound Feature Vector **88**, and the Infrared/Ultrasound Detect Decision Confidence Vector is produced from the Fused Feature Vector **81**.

Continuing in reference to FIG. **17**, these three independent detect decision confidence vectors, Infrared **410**, Infrared/Ultrasound **412**, and Ultrasound **414**, are inputs to a Detection Fusion Processor **416**, which produces a Feature State **83**. The manner in which the Feature State decision is arrived at includes weighing functions associated with each confidence vector and weighting of recent decision history stored in a History Buffer **418**. For example, in the case of an RFCS, from analytical and empirical studies, we have found that the infrared feature is a "weak" indicator, the ultrasound feature is a "strong" indicator, and the combined infrared/ultrasound fused feature is a "moderately strong" indicator. With these three features, more weight will be applied to an ultrasound declared RFCS state, less weight will be applied to the fused feature declared RFCS state, and even less weight to a infrared declared RFCS state. In this fashion, the three detect decision vectors, the IR Detect Decision Confidence Vector, the US Detect Decision Confidence Vector, The IR/US Detect Decision Vector, are weighed and combined to produce a single vector with a corresponding confidence value for each of the states. The state with highest confidence value is selected as the feature state.

To summarize Feature state processing, by using the feature vector and the time-adjusted confidence criteria matrix as input, the processor performs essentially a look-up table function for the confidence levels on each vector component or fused vector component for each state. In this manner, decision making is made independently at the infrared, ultrasound, and infrared/ultrasound feature level. Furthermore, in this process, some features do not provide information on some of the states because these features alone are not dependable to make correct decisions for these states. Although some features are not reliable to make correct decisions for some of the states, in combination, these features are reliable to cover all the states, and this is the power behind the use of multiple feature fusion from the different sensors.

Note the above described preferred process involves first extracting features from raw sensory data, then producing fused features, associating confidence levels with the features and fused features to produce confidence levels for the predefined states, and determining a feature state from the confidence levels of the states. This process employs fusion at the feature level and at the detection level; it is not simple error correction routines. Other fusion methods can be employed within the principles of the present invention. An algorithm can also be used under certain circumstances to fuse the raw sensory data before any feature is extracted. An algorithm can be employed to extract features and produce a feature state from all the features extracted. Similarly, an algorithm can be utilized to extract features from each sensor, produce a state for each sensor, and fuse the states to produce a feature state. In other words, fusion of data can be done at the raw data level, feature level, decision level, or combination thereof, and any one of the above algorithm or combination thereof can be used for the present invention. The preferred embodiment utilizes a combination of fusion at the feature level and at the detection level, and the empirical comparison studies demonstrate this preferred combination provides superior accuracy in detection and discrimination for highly reliable decision.

Referring now to Decision Processing **84** (E) in FIGS. **14** and **22**, the Decision Confidence Processor **500** compares the Feature State (D') against a Current State **502**, State Change Criteria **503** stored in Memory **504**, a History Buffer **506**, and a System Health Status Buffer **508**. The Current State is the state condition as determined by the sensor system, i.e. what the sensor system indicates is the state of the passenger seat, and the corresponding signal to maintain an enable or disenable signal to the air bag controller. If the presently sensed Feature State is the same as the Current State, the Current State is not changed and the History Buffer store the Feature State. If the Feature State is different from the Current State, the Decision Confidence Processor determines whether the Feature State should become the Current State. For the Current State to become the Feature State, it must satisfy the State Change Criteria stored in Memory, which is a set of predetermined criteria to ensure the highest level of safety and reliability in the decision to enable or disenable air bag deployment. The set of predetermined criteria generally requires that more confirmations be made before changing from a deployment state to a non-deployment state, and less confirmations be made in going from a non-deployment state to a deployment state. The Decision Confidence Processor also looks at the history (since start-up of the vehicle) of the Current States stored in the History Buffer and considers what Current State decisions has been made and how often has the Current State been changed. The History Buffer is updated by the Decision Confidence Processor.

In addition, a Diagnostic Controller **510** checks sensor system integrity and updates the System Health Status Buffer. The Diagnostic Controller provides a System Health **512** indicator to the air bag controller and the vehicle's indicator panel. In case of system failure, the air bag controller defaults to the air bag deployment condition, e.g., by not sending an interrupt to the air bag controller. The Decision Confidence Processor checks the System Health Status Buffer and the other system conditions to ensure the sensor system is functioning properly.

As an example of a state change decision process, if the Current State is the Empty state with the corresponding signal to disenable the air bag and the Feature State is the Occupant state, the Decision Confidence Processor will check the System Health Status Buffer to ensure proper system integrity. It will also check the History Buffer to see how many of the previous consecutive periods has the Feature State been the Occupant state or how often has the Current State been changed. The Decision Confidence Processor will change the Current State from Empty state to Occupant state if, during the last two periods, for example, the Feature State has been the Occupant state. On the other hand, if the Current State has been the Occupant state, it will take much more than two periods to change the Current State from the Occupant state to the Empty state. If the current state has been changed quite a few times previously, it will be increasingly more difficult to change the current state from occupant to empty state. This is because the preferred embodiment biases decisions regarding state change toward safety.

FIG. **23** shows, in the case of detecting a front facing occupant and permitting the air bag to deploy, while inhibiting deployment if an RFCS is detected, that the dual sensor system of the invention provides very high functional reli-

ability. The reliability, R, of 0.98 (98%) or greater is obtained using sensor fusion even where the probability of detection P_D, for Sensor 1 is as low as 0.3 and the probability of false detection, P_{FA}, is as high as 10^{-4} (R of 0.27), single Sensor 2 has a P_D of 0.99 and P_{FA} is 10^{-6}.

The AOS of this invention can even recognize the vehicle it is in by measuring the relative position of the module and the interior attributes of the vehicle. FIG. *24a* shows actual measurements performed by the above-described AOS system in a Chrysler LH vehicle. The scope trace shows the actual time referenced acoustic returns from the test vehicle, the layout of which is shown in FIG. *24b*. FIG. *25a* shows actual measurements performed in a 1989 Dodge pickup truck of layout shown in FIG. *25b*. Table 1 below shows the actual timing values measured by the AOS system. These results show a signal margin of 1060 μs at the IP measurement mark, 257 μs at the seat position mark and 543 μs at the floor mark. The total time difference is 1860 μs. With a time resolution of better than 20 μs, the AOS has a large signal processing margin when identifying the difference between vehicles such as a Chrysler LH and RAM truck. Comparison of the traces of FIGS. *24a* and *25a* show the unique signatures of the vehicle interior configurations by which the AOS of this invention can recognize the vehicle, and a normal state thereof.

TABLE 1

	LH	TRUCK
IP Return	2804 μs	3864 μs
Seat Return	5297 μs	5040 μs
Floor Return	6933 μs	7476 μs

we have measured several types of significant data to evaluate the potential performance of the AOS. This data shows excellent signal to noise ratios (SNR) and a large design performance margin from the sensor suite. The signal to noise values and resulting predicted performance are summarized in FIG. 26. The Pd numbers in FIG. 26 were calculated using the 4-feature fused probability equation shown below.

$$R_{1,2,3,4}=R_1+R_2+R_3+R_4-R_1(R_2+R_3+R_4)-R_2(R_3+R_4)-R_3R_4+R_1(R_2R_4+R_3R_4)+R_2(R_3R_4+R_1R_3)-R_1R_2R_3R_4$$

The individual probability inputs to the equation were derived from actual measurements and worst case analysis.

Testing conducted on typical IR detectors yielded SNR in the range of 12:1 from a normal occupant in an 83° F. vehicle. The ultrasound sensor yields a SNR of 16:1 during the same type of test. By way of comparison, the ultrasound sensor return from a rear facing child seat was measured with the RFCS both uncovered and covered with two wool blankets. The child seat was a Century brand and was placed in a 1993 Eagle Vision. The uncovered child seat gave an SNR of 20:1 while the seat covered under two blankets generated a SNR of 11:1. These signal traces are shown in FIGS. *27a* and *27b*, respectively. This data indicates that the system of the invention can easily discriminate even between these two subtly different occupant states.

The measurements reflected in FIGS. 22–27 were taken under static conditions in the laboratory. Assuming that under worst case conditions, the signals would be degraded by about a factor of 4, all SNR data was divided by 4. With only small gains in signal processing, the data was increased by a factor of 2. This small signal processing gain does not include using any adaptive thresholding or historical inputs in the detection process which are standard techniques that can provide substantially increased signal processing gain. Because this is a worst case analysis, such adaptive and historical gains are not included.

Using the adjusted worst case system performance numbers, detection probabilities for each sensing mode were calculated. The calculation assumptions used here were simple envelope detection using fixed thresholds in a Gaussian noise distribution, whereas the AOS of the invention uses more sophisticated detection processes and has higher individual detection probabilities to ensure adequate Pd under all conditions. The individual sensor mode detection probabilities are shown in FIG. 26, and were used to calculate the fused detection probability shown in the right hand column of FIG. 26. For this analysis a life of 15 million cycles was assumed. The probability of false alarm for this analysis was set at one in a million cycles. The false alarm probability will be reduced to an even smaller number when history and adaptive processing gains are considered. Not including these gains shows worst case system performance.

Diagnostic reliability also benefits from multi-sensor fusion much the same way that detection benefits. As shown in FIG. 26 when each sensor diagnostic probability is fused, the resultant system diagnostic probability is increased. As was done for the detection analysis, the diagnostic probability numbers began as lab measurements that were adjusted downward for worst case conditions., then adjusted for worst case signal processing gain. These individual probabilities were taken from Gaussian noise and a false alarm rate of one in a 100 million cycles.

Both IP (Instrument Panel or Dashboard) and overhead locations were evaluated and tested for operability. High reliability occupant and rear facing child seat detection can be performed from both the IP and the overhead position. Both the IR and the ultrasonic sensor performance has been determined to be location independent.

The overhead sensor position offers system performance advantages over the instrument panel (IP) mounting position. The overhead position is much harder to intentionally block by normal occupant behavior. In the overhead position, the relative geometry of the vehicle is much more easily measured. This feature allows an overhead mounted AOS to measure the relative position of the IP, the seat and the floor, and determine the type of vehicle the AOS has been placed in.

it should be understood that various modifications within the scope of this invention can be made by one of ordinary skill in the art without departing from the spirit thereof. For example, the memory and history buffers can be used to store the state decision for a predetermined period (say 60 to 600 seconds depending on size of memory supplied in the ASIC or microprocessor) prior to a crash in order to determine what the occupants did prior to or during the crash. Was a dog out of position, a passenger make unusual motions indicative of distractions or intrusions, etc? This may be dumped from time to time into a special memory in a crash "black box" along with other vital vehicle operating data, fuel level, speed, acceleration/deceleration, change of direction, braking, lights and/or wipers-on, interior climate and the like. We therefore wish our invention to be defined by the scope of the appended claims as broadly as the prior art will permit, and in view of the specification if need be.

We claim:

1. A method for determining whether or not to de-activate a vehicle's passenger passive restraint system as a function of a current state value determined by comparing measured signal features to a predetermined set of confidence values and empirical relationships obtained using various known

occupancy scenarios and a set of state change criteria, comprising the steps of:

(a) sensing the characteristics of occupancy of a particular passenger seat within the vehicle using a plurality of sensors functionally associated with said passenger seat and developing a set of corresponding electrical signals;

(b) evaluating said electrical signals to determine a plurality of signal features included in each of said signals;

(c) combining certain ones of said signal features to obtain a plurality of fused features;

(d) associating said signal features and said fused features with the confidence values and empirical relationships to determine a feature state value;

(e) identifying the feature state value as the current state value if the set of state change criteria is met; and

(f) generating a de-activate signal if said current state value is one of a predetermined subset of state values for which said passive restraint system is to be de-activated.

2. A method according to claim 1, wherein said passenger passive restraint system includes an air bag deployment system having an air bag that is located for deployment proximate said passenger seat and that can be de-activated in response to said de-activate signal.

3. A method according to claim 2, wherein said predetermined set of state values includes values corresponding to an empty seat state, an occupied seat state, a rear-facing child seat state, an out-of-position passenger state, and an inanimate object state.

4. A method according to claim 3, wherein:

(a) the occupied seat state corresponds to the scenarios of a person seated in said seat, a person seated in said seat holding a grocery bag, a child in a forward-facing child seat disposed in said seat, a child standing in said seat at a distance from the air bag deployment location, and a pet disposed in said seat;

(b) the rear-facing child seat state corresponds to the scenario of a child in a rear-facing child seat disposed in said seat;

(c) the out-of-position passenger state corresponds to the scenario of a person positioned in close proximity to the air bag deployment location;

(d) the inanimate object state corresponds to the scenario of an inanimate object disposed in said seat; and

(e) the empty seat state corresponds to the scenario of an empty seat.

5. A method according to claim 2, wherein said occupancy scenarios include a person seated in said passenger seat, a person seated in said seat holding a grocery bag, a child in a rear-facing child seat disposed in said seat, a child in a forward-facing child seat disposed in said seat, a child in a forward-facing child seat disposed in said seat, a person positioned in close proximity to the air bag deployment location, a child standing in said seat at a distance from the air bag deployment location, a standing child in close proximity to the air bag deployment location, an empty seat, an inanimate object disposed in said seat, a pet disposed in said seat, and an empty seat.

6. A method according to claim 1, wherein said plurality of sensors is selected from the group consisting of infrared sensors, ultrasound sensors, weight sensors, microwave sensors, light sensors, and laser sensors.

7. A method according to claim 6, wherein said sensing step includes the use of two infrared detectors placed close to each other and separated by a baffle.

8. A method according to claim 7, wherein said sensing step further includes using a multi-element Fresnel lens to focus one detector on a seat back of the passenger seat and to focus the other detector on a seat surface of the passenger seat.

9. A method according to claim 1, wherein said signal features include indicia of (a) motion, (b) frequency of motion, (c) levels of motion, (d) difference in motion levels, (e) distance, (f) relative distance, (g) thermal levels, and (h) difference in thermal levels.

10. A method according to claim 9, wherein said indicia of motion include indicia of lateral notion and longitudinal motion.

11. A method according to claim 1, wherein said fused features include indicia of (a) temperature, (b) temperature differences, (c) approximate size of objects, (d) distance, (e) motion, (f) frequency of motion, and (g) levels of motion.

12. A method according to claim 1, wherein said associating step (d) comprises the substeps of:

i) using predetermined confidence values and said signal features and fused features to produce (1) a decision confidence matrix of confidence values for the signal features of the signals of each sensor, and (2) a decision confidence matrix of confidence values for said fused features;

ii) using the empirical relationships to calculate a decision confidence vector corresponding to each of said decision confidence matrices;

iii) weighing each decision confidence vector in a predetermined manner to produce weighted vectors; and

iv) combining the weighted vectors to produce a resultant vector having state values from which the feature state value is selected.

13. A method according to claim 1, wherein said set of state change criteria includes consideration of previous feature state values and previous current state values.

14. A method according to claim 1, wherein the subset of said predetermined set of state values, for which said passive restraint system is to be de-activated, includes state values corresponding to a rear-facing child seat state, an empty seat state, an inanimate object state, and an out-of-position state.

15. A method according to claim 1, wherein said passive restraint system includes a single canister air bag deployment system.

16. A method according to claim 1, wherein said passive restraint system includes a multi-canister air bag deployment system capable of partially pressurizing an air bag to various degrees of pressure.

17. A method according to claim 12, further comprising modifying said confidence values over time to correspond to changes in environmental conditions of the vehicle.

18. A method according to claim 1, wherein said sensing step includes using an ultrasound sensor to transmit ultrasonic pulses and to receive ultrasonic return signals.

19. A method according to claim 18, further comprising varying the transmission times between said ultrasonic pulses.

20. A method as recited in claim 1, wherein said plurality of sensors include:

(a) a first infrared detector for generating a first raw data signal;

(b) a second infrared detector for generating a second raw data signal; and

(c) an ultrasound detector for generating a third raw data signal; and wherein said evaluating step (b) includes:

i) processing said first and second raw data signals to develop a first set of signals representing a first group of signal features and defining an infrared feature vector signal;

ii) processing said third raw data signal to develop a second set of signals representing a second group of signal features and defining an ultrasound feature vector signal;

iii) selecting a subset of said first group of signal features to develop a third group of signal features defining an infrared feature vector subset signal; and

iv) selecting a subset of said second group of signal features to develop a fourth group of signal features defining an ultrasound feature vector subset signal.

21. A method as recited in claim 20 wherein said combining step includes processing said infrared feature vector subset signal and said ultrasound feature vector subset signal to develop a fused feature vector signal.

22. A method as recited in claim 21, wherein the processing of said infrared feature vector subset signal and said ultrasound feature vector subset signal includes:

(a) correlating a first subset of said third group of signal features with a first subset of said fourth group of signal features to develop an infrared spatial frequency components signal;

(b) processing a second subset of said third group of signal features with a second subset of said fourth group of signal features to develop an infrared first absolute surface temperature signal, an infrared second absolute surface temperature signal, and an infrared differential absolute surface temperature signal;

(c) processing a third subset of said third group of signal features with a third subset of said fourth group of signal features to develop an infrared/ultrasound motion level correlation signal, an infrared/ultrasound motion level temporal correlation signal, and an infrared/ultrasound motion frequency correlation signal; and

(d) the infrared spatial frequency components signal, the infrared first absolute surface temperature signal, the infrared second absolute surface temperature signal, the infrared differential absolute surface temperature signal, the infrared/ultrasound motion level correlation signal, the infrared/ultrasound motion level temporal correlation signal, and the infrared/ultrasound motion frequency correlation signal are to form said fused feature vector signal.

23. A method as recited in claim 22, wherein the signals representing the first group of said signal features include a first infrared lateral motion frequency signal, a first infrared thermal temporal signal, a first infrared thermal level signal, a first infrared lateral motion temporal signal, a first infrared lateral motion level signal, an infrared longitudinal motion level signal, an infrared differential motion level signal, an infrared differential motion temporal signal, an infrared differential motion frequency signal, a second infrared lateral motion frequency signal, a second infrared thermal temporal signal, a second infrared thermal level signal, a second infrared lateral motion temporal signal, and a second infrared lateral motion level signal.

24. A method as recited in claim 23, wherein the signals representing the second group of said signal features include an absolute range signal, a first return level rate of change signal, a first return level signal, an absolute range-1st return signal, a range motion signal, a range motion rate of change signal, a range motion temporal signal, a range motion frequency signal, a relative range level rate of change signal, a relative range level signal, a relative range value signal, a multipath triangulation signal, and an air temperature signal.

25. A method as recited in claim 24, wherein the signals representing the third group of said signal features include the first infrared lateral motion frequency signal, the first infrared thermal level signal, the first infrared lateral motion temporal signal, the infrared differential motion frequency signal, the second infrared lateral motion frequency signal, the second infrared thermal level signal, the second infrared lateral motion temporal signal, and the infrared differential motion frequency signal.

26. A method as recited in claim 25, wherein the signals representing the fourth group of said signal features include the absolute range signal, the absolute range-1st return signal, the range motion temporal signal, the range motion frequency signal, the relative range value signal, and the multipath triangulation signal.

27. A method as recited in claim 26, wherein the signals representing the first subset of said third group includes the first infrared lateral motion frequency signal, the second infrared lateral motion frequency signal, and the infrared differential motion frequency signal.

28. A method as recited in claim 27, wherein the signals representing second subset of said third group include the first infrared thermal level signal and the second infrared thermal level signal.

29. A method as recited in claim 28, wherein the signals representing the third subset of said third group include the first infrared lateral motion frequency signal, the second infrared lateral motion frequency signal, the first infrared lateral motion temporal signal, and the second infrared lateral motion temporal signal.

30. A method as recited in claim 29, wherein the signals representing the first subset of said fourth group include the absolute range signal, the absolute range-1st return signal, the relative range value signal, and the multipath triangulation signal.

31. A method as recited in claim 30, wherein the signals representing the second subset of said fourth group include the absolute range signal, and the absolute range-1st return signal.

32. A method as recited in claim 31, wherein the signals representing the third subset of said fourth group include the range motion temporal signal and range motion frequency signal.

33. Apparatus for determining whether or not to control a vehicle's passenger passive restraint system as a function of a current state value determined by comparing measured signal features to a predetermined set of confidence values and empirical relationships obtained using various known occupancy scenarios and a set of state change criteria, comprising:

(a) means for sensing the characteristics of occupancy of a passenger seat within the vehicle using a plurality of sensors functionally associated with said passenger seat and a set of corresponding electrical signals;

(b) means for evaluating said electrical signals to determine a plurality of signal features included in each of said signals;

(c) means for combining certain ones of said signal features to obtain a plurality of fused features;

(d) means for associating said signal features and said fused features with the confidence values and empirical relationships to determine a feature state value;

(e) means for identifying the feature state value as the current state value if the set of state change criteria is met; and

(f) means for generating a state of control signal if said current state value is one of a predetermined set of state values for which said passive restraint system is to be controlled, including possible deactivation of said restraint system.

34. Apparatus according to claim 33, wherein said passenger passive restraint system includes an air bag deployment system having an air bag that is poised for deployment proximate said passenger 'seat and that can be de-activated or inflation controlled in response to said state of control signal.

35. Apparatus according to claim 34, wherein said predetermined set of state values includes values corresponding to an empty seat state, an occupied seat state, a rear-facing child seat state, an out-of-position passenger state, and an inanimate object state.

36. Apparatus according to claim 35, wherein:

(a) the occupied seat state corresponds to the scenarios of a person seated in said seat, a person seated in said seat holding a grocery bag, a child in a forward-facing child seat disposed in said seat, a child standing in said seat at a distance from the air bag deployment location, and a pet disposed in said seat;

(b) the rear-facing child seat state corresponds to the scenario of a child in a rear-facing child seat disposed in said seat;

(c) the out-of-position passenger state corresponds to the scenario of a person positioned in close proximity to the air bag deployment location;

(d) the inanimate object state corresponds to the scenario of an inanimate object disposed in said seat; and

(e) the empty seat state corresponds to the scenario of an empty seat.

37. Apparatus according to claim 34, wherein said occupancy scenarios include a person seated in said passenger seat, a person seated in said seat holding a grocery bag, a child in a rear-facing child seat disposed in said seat, a child in a forward-facing child seat disposed in said seat, a person positioned in close proximity to the air bag deployment location, a child standing in said seat at a distance from the air bag deployment location, a standing child in close proximity to the air bag deployment location, an empty seat, an inanimate object disposed in said seat, a pet disposed in said seat, and an empty seat.

38. Apparatus according to claim 33, wherein said plurality of sensors is selected from the group consisting of infrared sensors, ultrasound sensors, weight sensors, microwave sensors, light sensors, and laser sensors.

39. Apparatus according to claim 38, wherein said means for sensing includes two infrared detectors placed close to each other and separated by a baffle.

40. Apparatus according to claim 39, wherein said means for sensing further includes a multi-element Fresnel lens for focusing one detector on the seat back of the passenger seat and for focusing the other detector on the seat surface of the passenger seat.

41. Apparatus according to claim 33, wherein said signal features include indicia of (a) motion, (b) frequency of motion, (c) levels of motion, (d) difference in motion levels, (e) distance, (f) relative distance, (g) thermal levels, and (h) difference in thermal levels.

42. Apparatus according to claim 41, wherein said indicia of motion include indicia of lateral motion and longitudinal motion.

43. Apparatus according to claim 33, wherein said fused features include indicia of (a) temperature, (b) temperature differences, (c) approximate size of objects, (d) distance, (e) motion, (f) frequency of motion, and (g) levels of motion.

44. Apparatus according to claim 33, wherein said means for associating comprises:

i) means for using predetermined confidence values and said signal features and fused features to produce (1) a decision confidence matrix of confidence values for the signal features of the signals of each sensor, and 2 a decision confidence matrix of confidence values for said fused features;

ii) means for using the empirical relationships to calculate a decision confidence vector corresponding to each of said decision confidence matrices;

iii) means for weighing each decision confidence vector in a predetermined manner to produce weighted vectors; and

iv) means for combining the weighted vectors to produce a resultant vector having state values from which the feature state value is selected.

45. Apparatus according to claim 33, wherein said set of state change criteria includes consideration of previous feature state values and previous current state values.

46. Apparatus according to claim 33, wherein the subset of said predetermined set of state values, for which said passive restraint system is to be de-activated, includes state values corresponding to a rear-facing child seat state, an empty seat state, an inanimate object state, and an out-of-position state.

47. Apparatus according to claim 33, wherein said passive restraint system includes a single canister air bag deployment system.

48. Apparatus according to claim 33, wherein said passive restraint system includes a multi-canister air bag deployment system capable of partially pressurizing an air bag to various degrees of pressure.

49. Apparatus according to claim 33, further comprising means for modifying said confidence values over time to correspond to changes in environmental conditions of the vehicle.

50. Apparatus according to claim 33, wherein said means for sensing includes an ultrasound sensor for transmitting ultrasonic pulses and for receiving ultrasonic return signals.

51. Apparatus according to claim 50, further comprising means for varying the transmission times between said ultrasonic pulses.

52. Apparatus as recited in claim 33, wherein said plurality of sensors of element (a) include:

i) a first infrared detector for generating a first raw data signal;

ii) a second infrared detector for generating a second raw data signal; and

iii) at least one ultrasound detector for generating at least one third raw data signal; and wherein said means for evaluating (b) includes:

i) means for processing said first and second raw data signals and for developing a first set of signals representing a first group of signal features and defining an infrared feature vector signal;

ii) means for processing said third raw data signal and for developing a second set of signals representing a second group of signal features and defining at least one ultrasound feature vector signal;

iii) means for selecting a subset of said first group of signal features to develop a third group of signal features defining an infrared feature vector subset signal; and

iv) means for selecting a subset of said second group of signal features to develop a fourth group of signal features defining at least one ultrasound feature

vector subset signal.

53. Apparatus as recited in claim 52 wherein said means for combining includes means for processing said infrared feature vector subset signal and said ultrasound feature vector subset signal to develop a fused feature vector signal.

54. Apparatus as recited in claim 53, wherein said means for processing said infrared feature vector subset signal and said ultrasound feature vector subset signal includes

(a) means for correlating a first subset of said third group of signal features with a first subset of said fourth group of signal features and for developing an infrared spatial frequency components signal;

(b) means for processing a second subset of said third group of signal features with a second subset of said fourth group of signal features and for developing an infrared first absolute surface temperature signal, an infrared second absolute surface temperature signal, and an infrared differential absolute surface temperature signal;

(c) means for processing a third subset of said third group of signal features with a third subset of said fourth group of signal features and for developing at least one infrared/ultrasound motion level correlation signal, an infrared/ultrasound motion level temporal correlation signal, and an infrared/ultrasound motion frequency correlation signal; and

(d) the infrared spatial frequency components signal, the infrared first absolute surface temperature signal, the infrared second absolute surface temperature signal, the infrared differential absolute surface temperature signal, the infrared/ultrasound motion level correlation signal, the infrared/ultrasound motion level temporal correlation signal, and the infrared/ultrasound motion frequency correlation signal are combined to form said fused feature vector signal.

55. Apparatus as recited in claim 54, wherein the signals representing the first group of said signal features include a first infrared lateral motion frequency signal, a first infrared thermal temporal signal, a first infrared thermal level signal, a first infrared lateral motion temporal signal, a first infrared lateral motion level signal, an infrared longitudinal motion level signal, an infrared differential motion level signal, an infrared differential motion temporal signal, an infrared differential motion frequency signal, a second infrared lateral motion frequency signal, a second infrared thermal temporal signal, a second infrared thermal level signal, a second infrared lateral motion temporal signal, and a second infrared lateral motion level signal.

56. Apparatus as recited in claim 55, wherein the signals representing the second group of said signal features include an absolute range signal, a first return level rate of change signal, a first return level signal, an absolute range-1st return signal, a range motion signal, a range motion rate of change signal, a range motion temporal signal, a range motion frequency signal, a relative range level rate of change signal, a relative range level signal, a relative range value signal, a multipath triangulation signal, and an air temperature signal.

57. Apparatus as recited in claim 56, wherein the signals representing the third group of said signal features include the first infrared lateral motion frequency signal, the first infrared thermal level signal, the first infrared lateral motion temporal signal, the infrared differential motion frequency signal, the second infrared lateral motion frequency signal, the second infrared thermal level signal, the second infrared lateral motion temporal signal, and the infrared differential motion frequency signal.

58. Apparatus as recited in claim 57, wherein the signals representing the fourth group of said signal features include at least one of: the absolute range signal, the absolute range-1st return signal, the range motion temporal signal, the range motion frequency signal, the relative range value signal, and the multipath triangulation signal.

59. Apparatus as recited in claim 58, wherein the signals representing the first subset of said third group includes the first infrared lateral motion frequency signal, the second infrared lateral motion frequency signal, and the infrared differential motion frequency signal.

60. Apparatus as recited in claim 59, wherein the signals representing second subset of said third group include the first infrared thermal level signal and the second infrared thermal level signal.

61. Apparatus as recited in claim 60, wherein the signals representing the third subset of said third group include the first infrared lateral motion frequency signal, the second infrared lateral motion frequency signal, the first infrared lateral motion temporal signal, and the second infrared lateral motion temporal signal.

62. Apparatus as recited in claim 61, wherein the signals representing the first subset of said fourth group include the absolute range signal, the absolute range-1st return signal, the relative range value signal, and the multipath triangulation signal.

63. Apparatus as recited in claim 62, wherein the signals representing the second subset of said fourth group include the absolute range signal, and the absolute range-1st return signal.

64. Apparatus as recited in claim 63, wherein the signals representing the third subset of said fourth group include the range motion temporal signal and range motion frequency signal.

65. An application specific integrated circuit device for processing sensory input signals received from sensors adapted to sense the characteristics of occupancy of a particular passenger seat within a vehicle, and for determining whether or not to de-activate a vehicle's passenger passive restraint system as a function of a current state value determined by comparing measured signal features to a predetermined set of confidence values and empirical relationships obtained using various known occupancy scenarios and a set of state change criteria, comprising in one or more chips:

(a) means for evaluating said input signals to determine a plurality of signal features;

(b) means for combining certain ones of said signal features to obtain a plurality of fused features;

(c) means for associating said signal features and said fused features with the confidence values and empirical relationships to determine a feature state value;

(d) means for identifying the feature state value as the current state value if the set of state change criteria is met; and

(e) means for generating a de-activate signal if said current state value is one of a predetermined set of state values for which said passive restraint system is to be de-activated.

* * * * *

EXHIBIT B

Patent US-6,272,411

US005482314A

United States Patent [19]

Corrado et al.

[11] Patent Number: 5,482,314

[45] Date of Patent: Jan. 9, 1996

[54] **AUTOMOTIVE OCCUPANT SENSOR SYSTEM AND METHOD OF OPERATION BY SENSOR FUSION**

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[73] Assignee: **Aerojet General Corporation**, Fairlawn, Ohio

[21] Appl. No.: **227,531**

[22] Filed: **Apr. 12, 1994**

[51] **Int. Cl.**[6] **B60R 21/32**

[52] **U.S. Cl.** **280/735**; 364/424.05; 307/10.1

[58] **Field of Search** .... 280/735, 734, 280/728 R, 730 R, 731, 732, 728.1, 730.1; 180/272; 307/10.1; 364/424.05; 340/565

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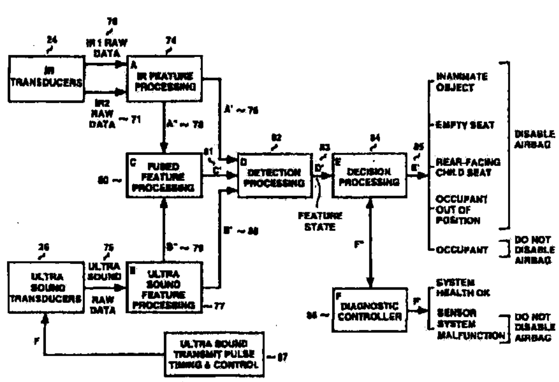
Primary Examiner—Margaret A. Focarino
Assistant Examiner—Peter C. English
Attorney, Agent, or Firm—Jacques M. Dulin

[57] **ABSTRACT**

A system for sensing the presence, position and type of an occupant in a passenger seat of a vehicle, as well as for sensing the presence of a rear-facing child seat therein, for use in enabling or disabling a related airbag activator. The sensor system employs sensor-fusion, a process of combining information provided by two or more sensors, each of which "sees" the world in a unique sense. In a preferred embodiment, occupancy sensor samples two detectable properties, a first being a thermal signature and associated motion, and a second is acoustically measured distance and the associated motion. Infrared sensor inputs and an ultrasonic sensor input are combined in a microprocessor circuit by means of a sensor fusion algorithm to produce an output signal to the air bag controller. The output signal results from preselected confidence weighing for feature parameters generated by the two sensors and upon a fusion process which ultimately makes a decision which is extremely reliable. The sensor fusion matrix processes the sensor outputs in a decision making operation which includes weighing inputs to guarantee reliability. All sensor outputs, along with calibration data, initial conditions and historical reference data are considered in the process of making a decision of whether or not to deploy the passenger-side air bag in a collision.

65 Claims, 17 Drawing Sheets



SIGNAL PROCESSOR FUNCTIONAL BLOCK DIAGRAM

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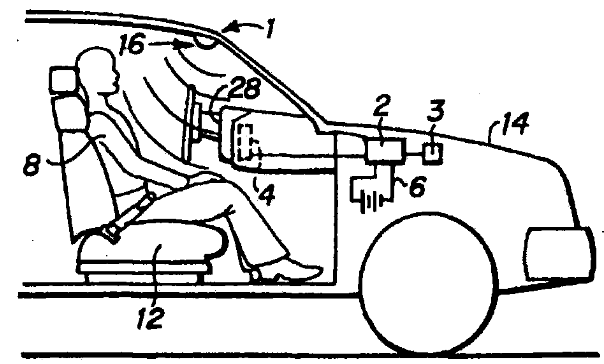


Fig_1

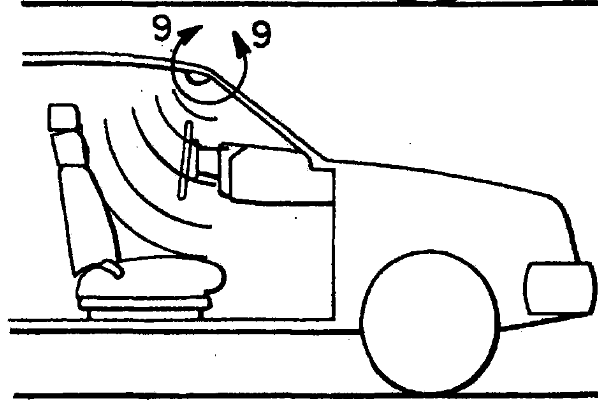


Fig_2

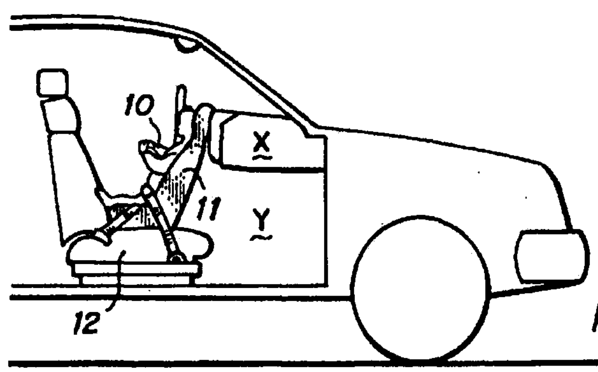


Fig_3

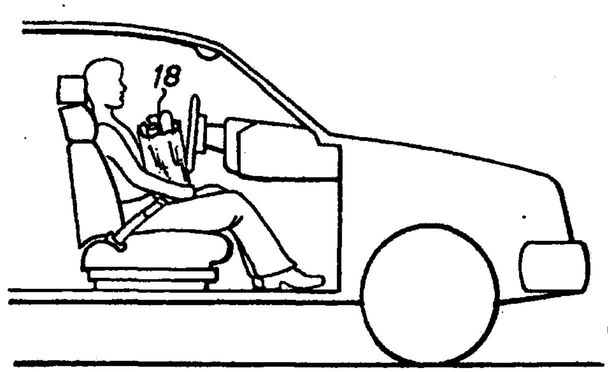
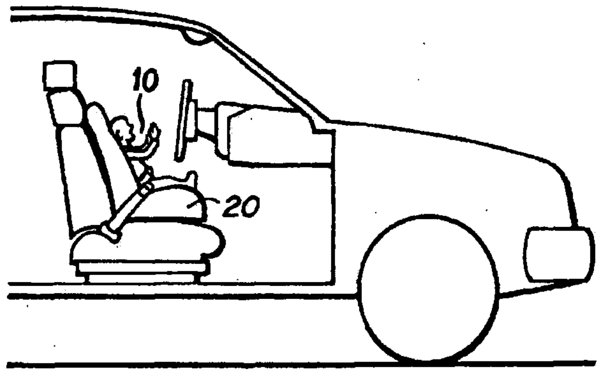


Fig_4



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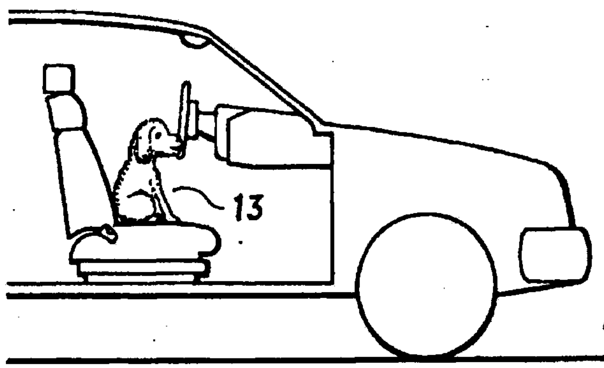


Fig_6

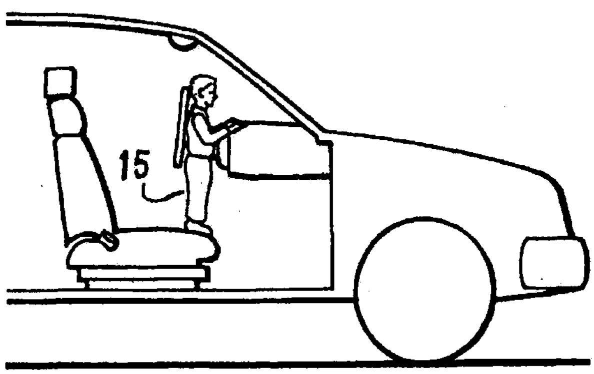


Fig.7

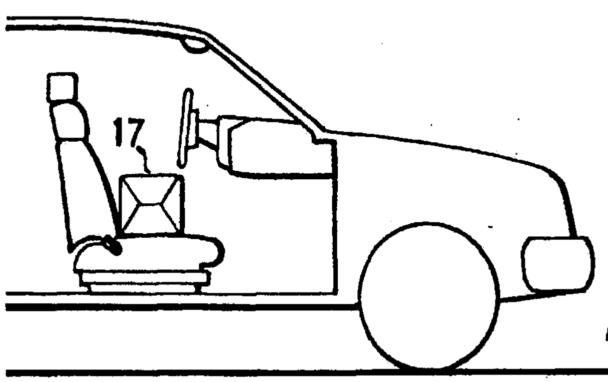


Fig.8

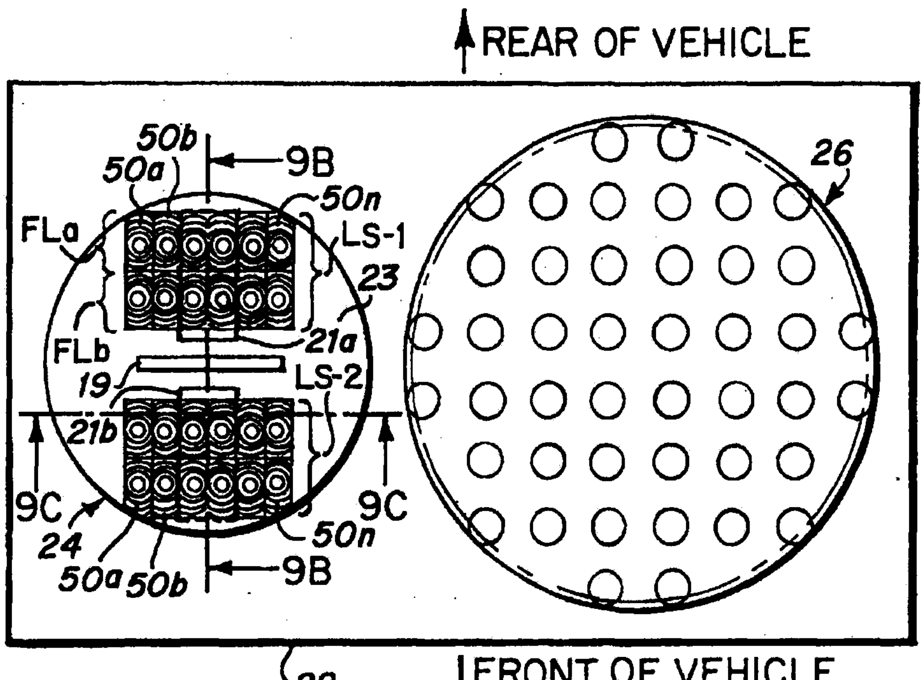


Fig.9A

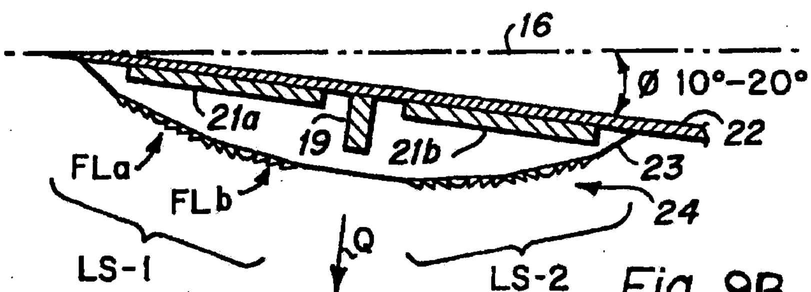


Fig_9B

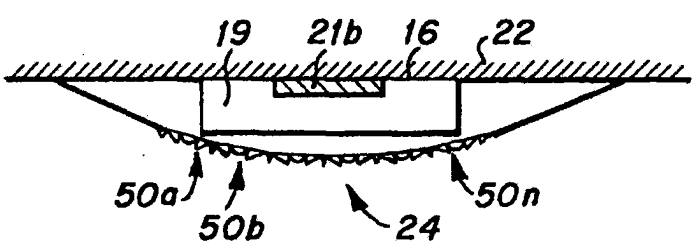


Fig.9C

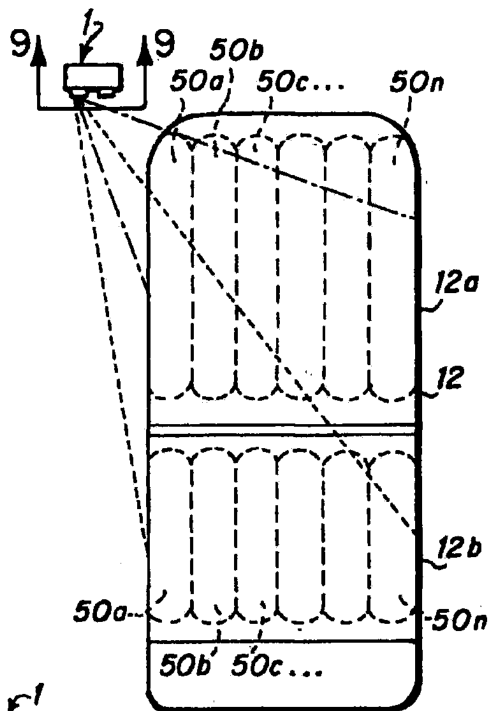


Fig_10

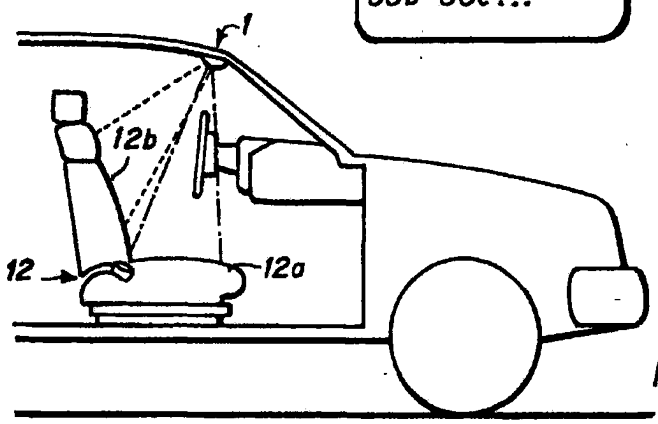


Fig_11a

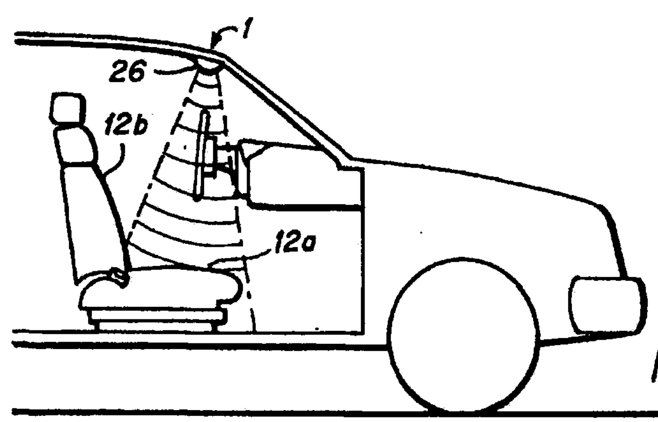
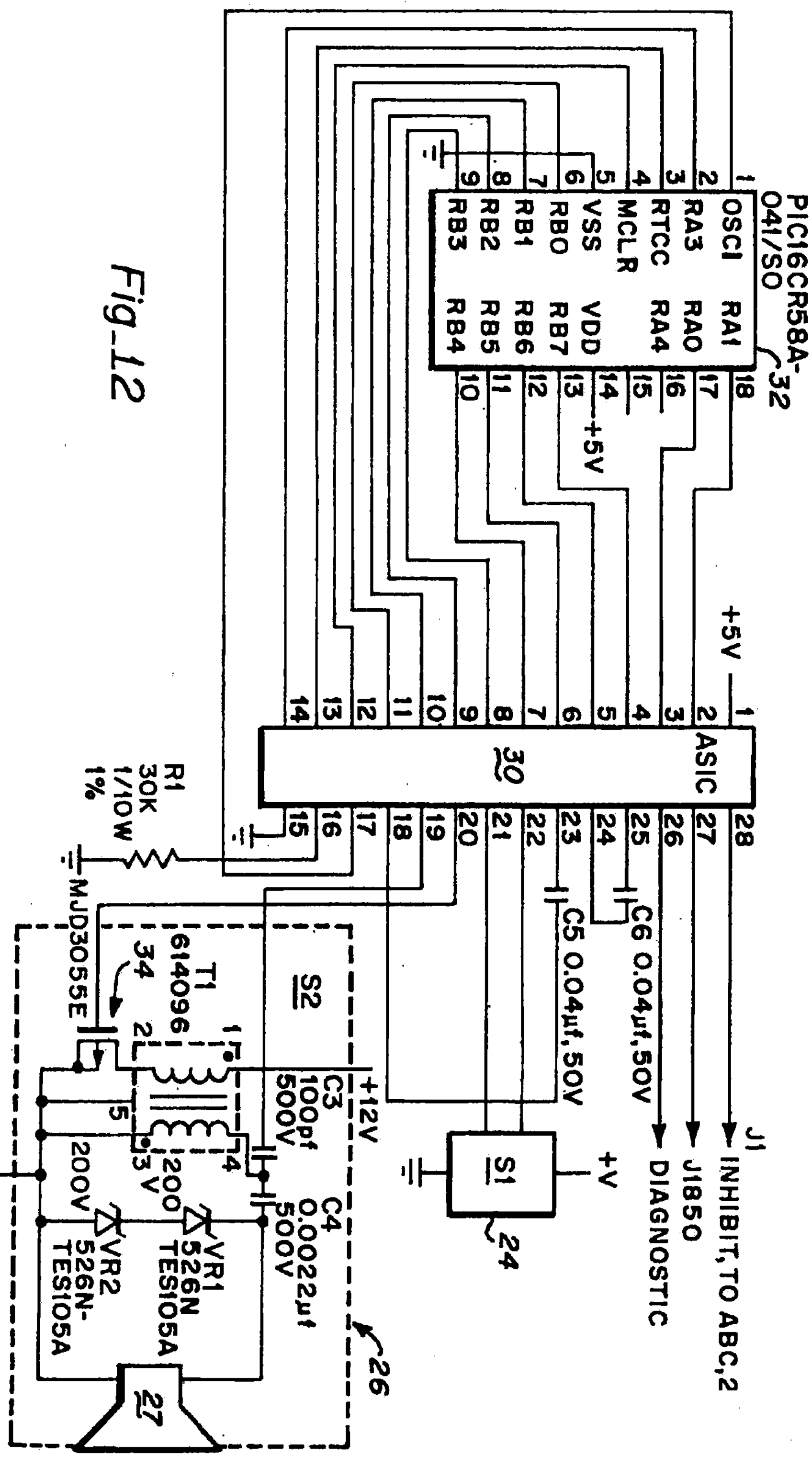


Fig_11b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OSCI
RA3
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VSS
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RB1
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RA1
RAO
RA4
VDD
RB7
RB6
RB5
RB4
+5V
ASIC
30
R1
30K
1/10W
1%
MJD3055E
C5 0.04µf,50V
C6 0.04µf,50V
J1
INHIBIT,TO ABC,2
J1850
DIAGNOSTIC
+V
S1
24
S2
T1
614096
34
+12V
C3
100pf
500V
C4
0.0022µf
500V
200V
200
3 V
VR1
526N
TES105A
VR2
526N-
TES105A
27
26

Fig_12

ASIC FUNCTIONAL DESCRIPTION

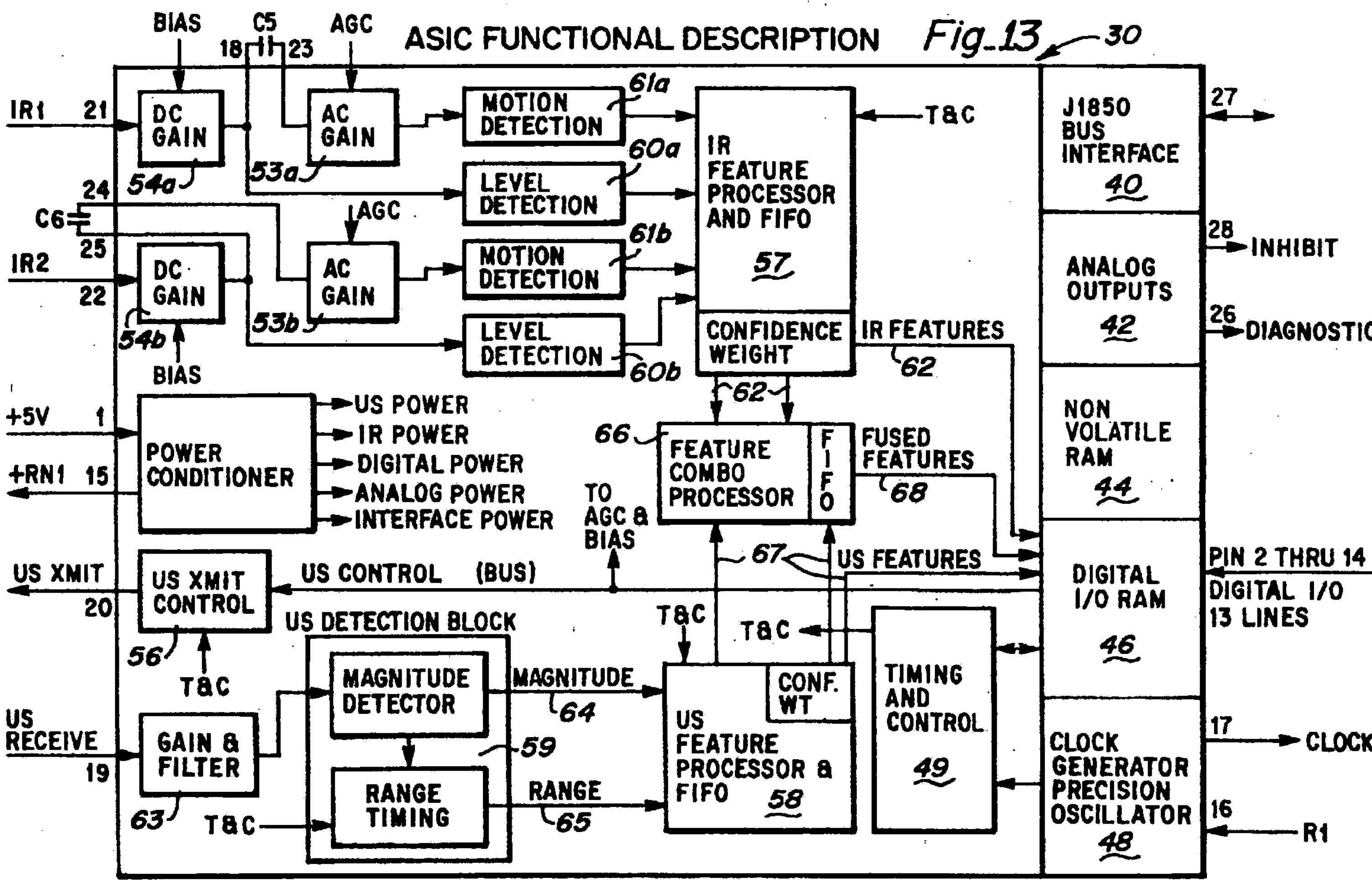


Fig_13

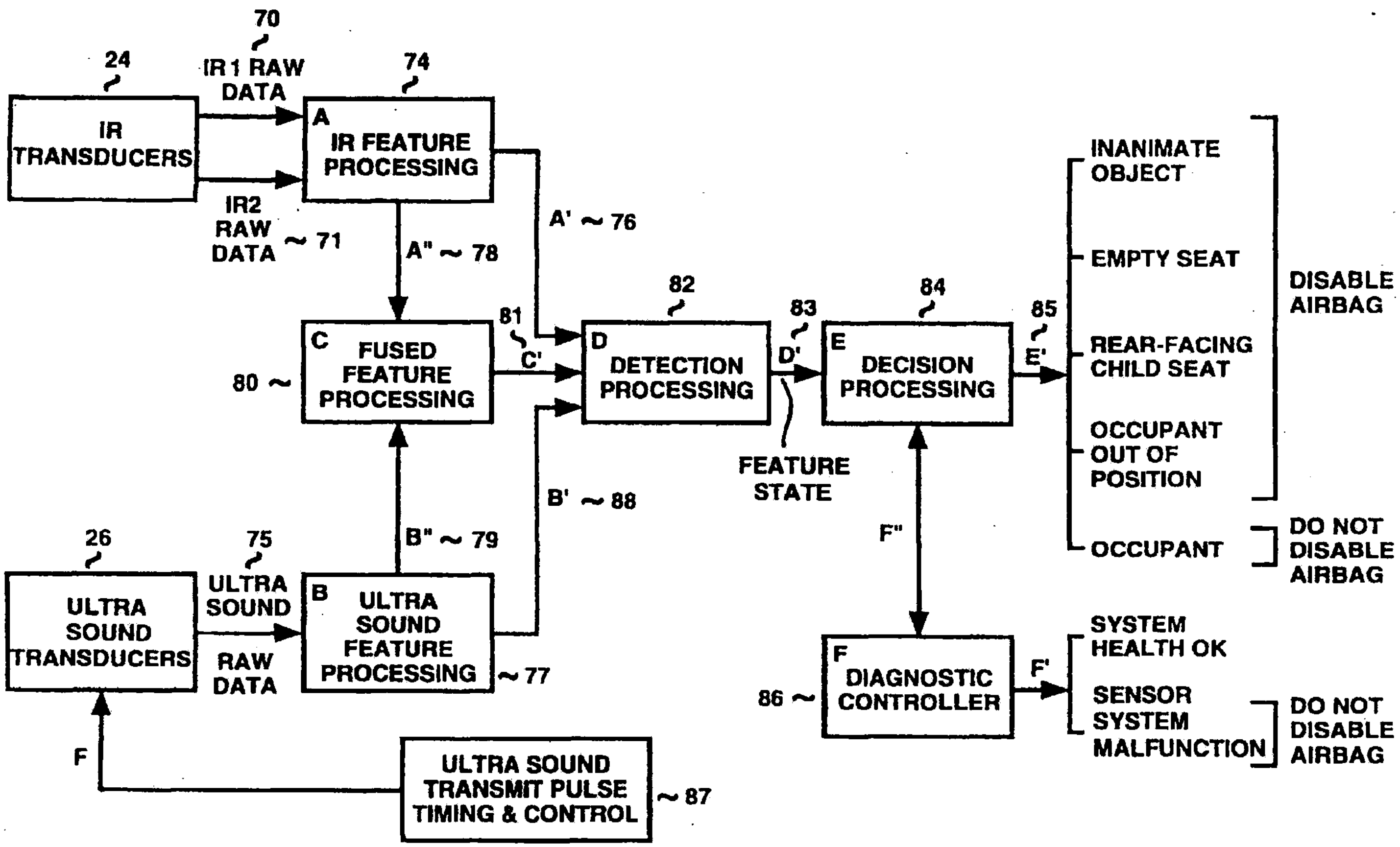
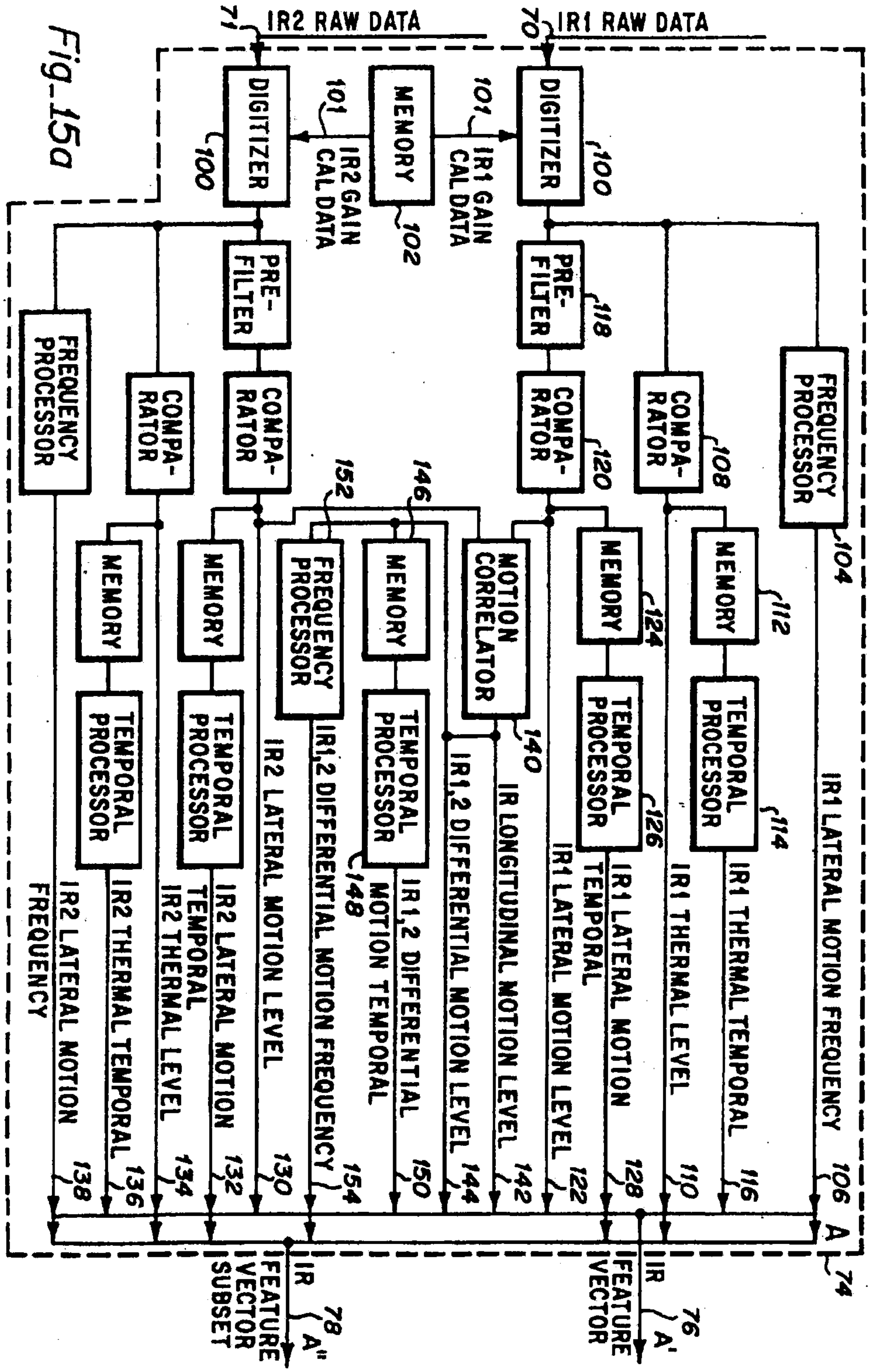


Fig. 14 SIGNAL PROCESSOR FUNCTIONAL BLOCK DIAGRAM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IR1 RAW DATA
DIGITIZER
DIGITIZER
MEMORY
IR2 GAIN CAL DATA
IR1 GAIN CAL DATA
PRE-FILTER
PRE-FILTER
COMPA-RATOR
COMPA-RATOR
COMPA-RATOR
COMPA-RATOR
FREQUENCY PROCESSOR
FREQUENCY PROCESSOR
FREQUENCY PROCESSOR
MEMORY
MEMORY
MEMORY
MEMORY
MEMORY
MOTION CORRELATOR
TEMPORAL PROCESSOR
TEMPORAL PROCESSOR
TEMPORAL PROCESSOR
TEMPORAL PROCESSOR
TEMPORAL PROCESSOR
IR1 LATERAL MOTION FREQUENCY
IR1 THERMAL TEMPORAL
IR1 THERMAL LEVEL
IR1 LATERAL MOTION TEMPORAL
IR1 LATERAL MOTION LEVEL
IR LONGITUDINAL MOTION LEVEL
IR1,2 DIFFERENTIAL MOTION LEVEL
IR1,2 DIFFERENTIAL MOTION TEMPORAL
IR1,2 DIFFERENTIAL MOTION FREQUENCY
IR2 LATERAL MOTION LEVEL
IR2 LATERAL MOTION TEMPORAL
IR2 THERMAL LEVEL
IR2 THERMAL TEMPORAL
IR2 LATERAL MOTION FREQUENCY
IR FEATURE VECTOR
IR FEATURE VECTOR SUBSET
A
A'
A"
70
71
74
76
78
100
101
102
104
106
108
110
112
114
116
118
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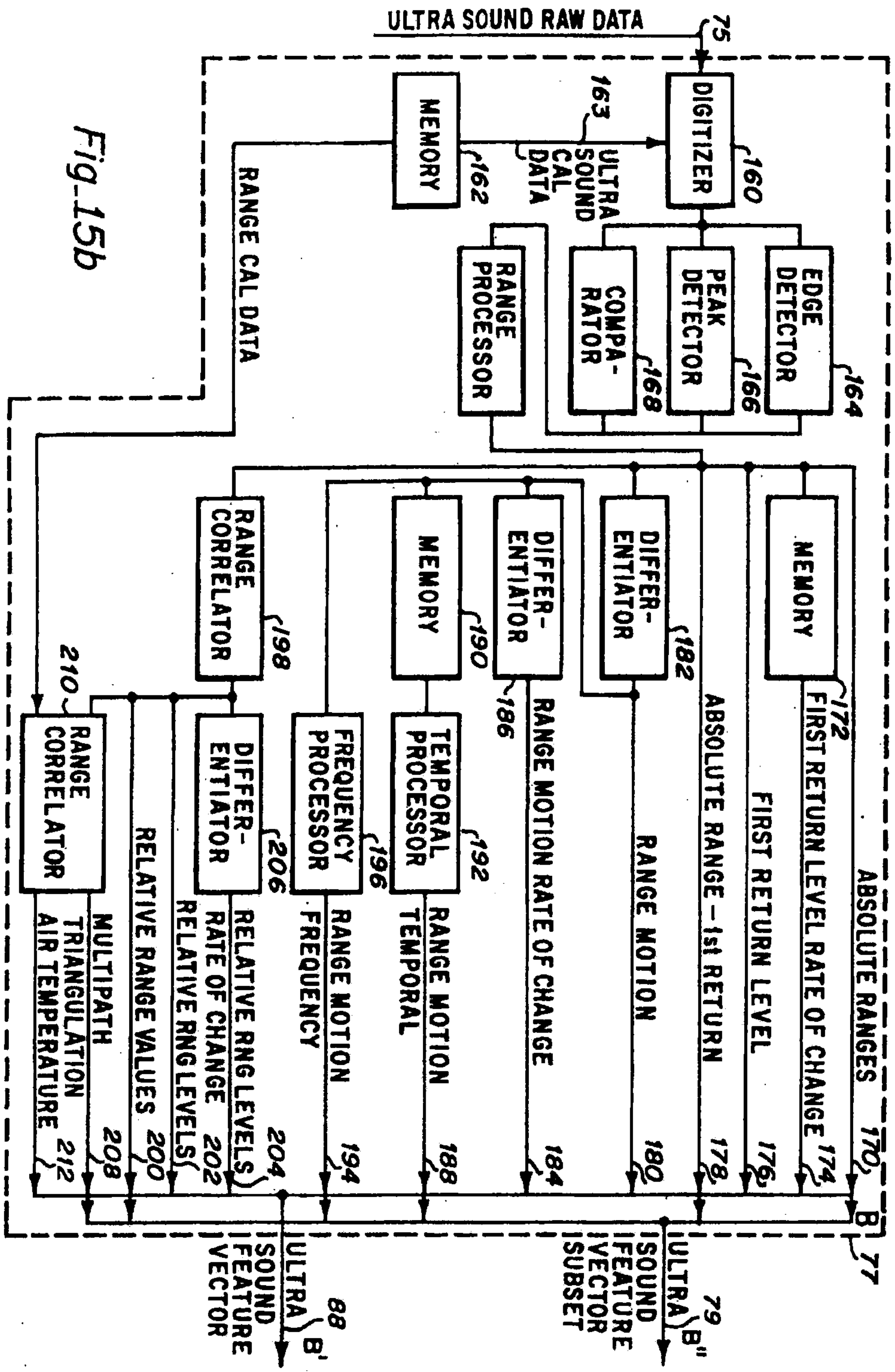
154

Fig_15a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MEMORY
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RANGE CAL DATA
EDGE DETECTOR
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PEAK DETECTOR
166
COMPA-RATOR
168
RANGE PROCESSOR
MEMORY
172
DIFFER-ENTIATOR
182
DIFFER-ENTIATOR
186
MEMORY
190
RANGE CORRELATOR
198
TEMPORAL PROCESSOR
192
FREQUENCY PROCESSOR
196
DIFFER-ENTIATOR
206
RANGE CORRELATOR
210
ABSOLUTE RANGES
170
FIRST RETURN LEVEL RATE OF CHANGE
174
FIRST RETURN LEVEL
176
ABSOLUTE RANGE—1st RETURN
178
RANGE MOTION
180
RANGE MOTION RATE OF CHANGE
184
RANGE MOTION TEMPORAL
188
RANGE MOTION FREQUENCY
194
RELATIVE RNG LEVELS RATE OF CHANGE
204
RELATIVE RNG LEVELS
202
RELATIVE RANGE VALUES
200
MULTIPATH TRIANGULATION
208
AIR TEMPERATURE
212
B
77
ULTRA SOUND FEATURE VECTOR SUBSET
79
B"
ULTRA SOUND FEATURE VECTOR
88
B'
Fig-15b

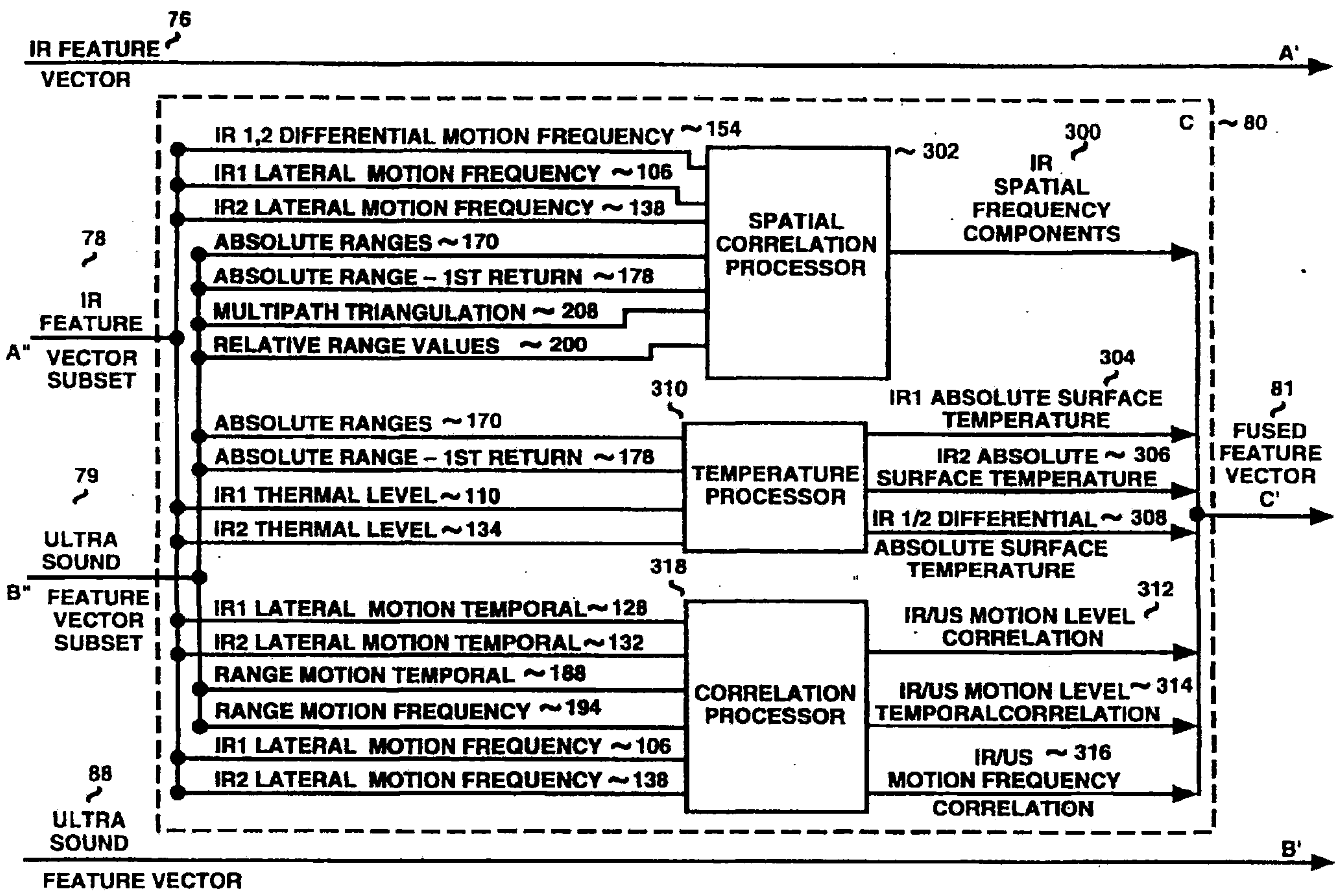

IR FEATURE VECTOR 76
A'
IR 1,2 DIFFERENTIAL MOTION FREQUENCY ~154
IR1 LATERAL MOTION FREQUENCY ~106
IR2 LATERAL MOTION FREQUENCY ~138
ABSOLUTE RANGES ~170
ABSOLUTE RANGE – 1ST RETURN ~178
MULTIPATH TRIANGULATION ~208
RELATIVE RANGE VALUES ~200
SPATIAL CORRELATION PROCESSOR ~302
IR SPATIAL FREQUENCY COMPONENTS 300
C ~80
78 IR FEATURE VECTOR SUBSET A"
ABSOLUTE RANGES ~170
ABSOLUTE RANGE – 1ST RETURN ~178
IR1 THERMAL LEVEL ~110
IR2 THERMAL LEVEL ~134
310 TEMPERATURE PROCESSOR
304 IR1 ABSOLUTE SURFACE TEMPERATURE
IR2 ABSOLUTE ~306 SURFACE TEMPERATURE
IR 1/2 DIFFERENTIAL ~308 ABSOLUTE SURFACE TEMPERATURE
81 FUSED FEATURE VECTOR C'
79 ULTRA SOUND FEATURE VECTOR SUBSET B"
IR1 LATERAL MOTION TEMPORAL ~128
IR2 LATERAL MOTION TEMPORAL ~132
RANGE MOTION TEMPORAL ~188
RANGE MOTION FREQUENCY ~194
IR1 LATERAL MOTION FREQUENCY ~106
IR2 LATERAL MOTION FREQUENCY ~138
318 CORRELATION PROCESSOR
312 IR/US MOTION LEVEL CORRELATION
IR/US MOTION LEVEL ~314 TEMPORALCORRELATION
IR/US ~316 MOTION FREQUENCY CORRELATION
88 ULTRA SOUND FEATURE VECTOR
B'

Figure 16

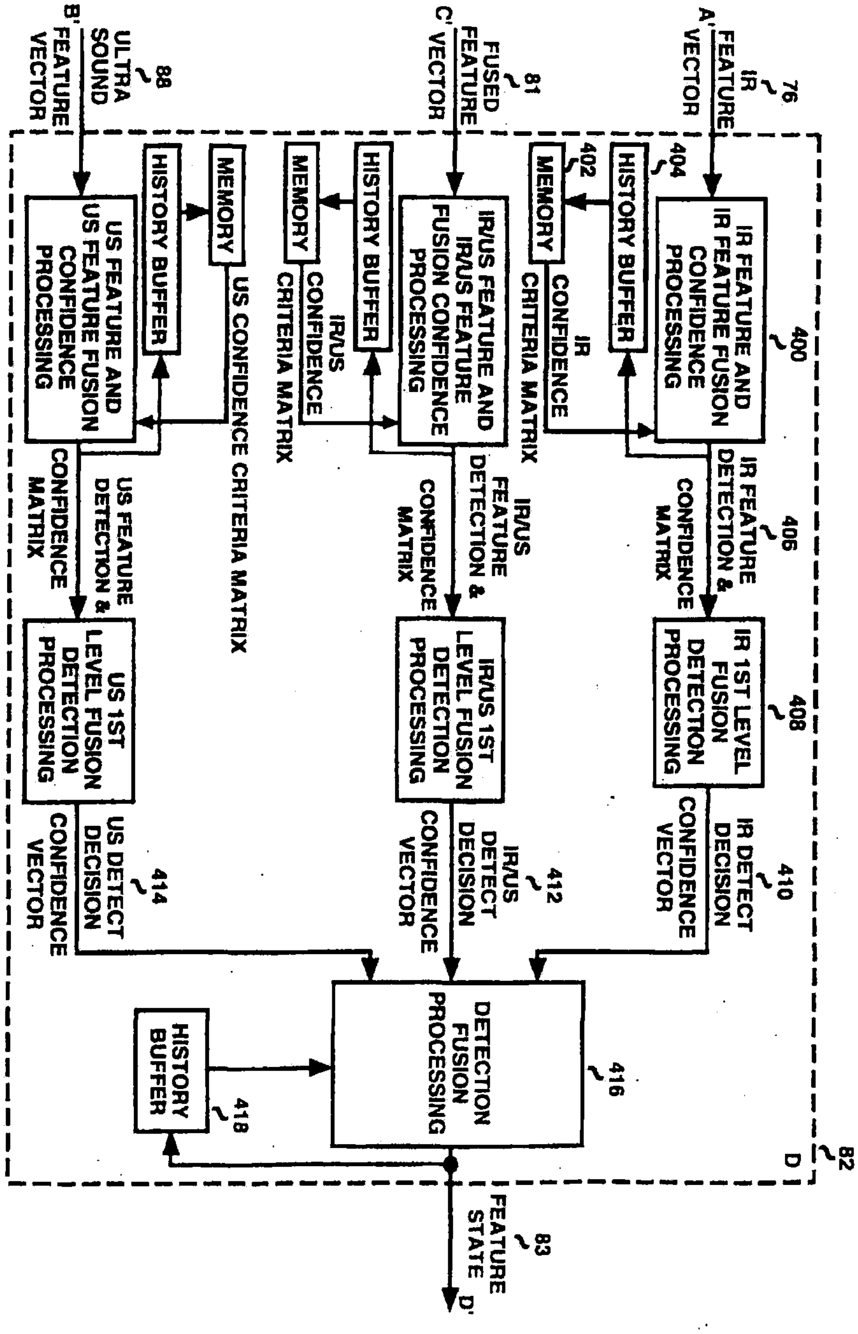

76
IR FEATURE VECTOR A'
81
FUSED FEATURE VECTOR C'
88
ULTRA SOUND FEATURE VECTOR B'
400
IR FEATURE AND IR FEATURE FUSION CONFIDENCE PROCESSING
404
HISTORY BUFFER
402
MEMORY
IR CONFIDENCE CRITERIA MATRIX
IR/US FEATURE AND IR/US FEATURE FUSION CONFIDENCE PROCESSING
HISTORY BUFFER
MEMORY
IR/US CONFIDENCE CRITERIA MATRIX
US FEATURE AND US FEATURE FUSION CONFIDENCE PROCESSING
HISTORY BUFFER
MEMORY
US CONFIDENCE CRITERIA MATRIX
406
IR FEATURE DETECTION & CONFIDENCE MATRIX
IR/US FEATURE DETECTION & CONFIDENCE MATRIX
US FEATURE DETECTION & CONFIDENCE MATRIX
408
IR 1ST LEVEL FUSION DETECTION PROCESSING
IR/US 1ST LEVEL FUSION DETECTION PROCESSING
US 1ST LEVEL FUSION DETECTION PROCESSING
410
IR DETECT DECISION CONFIDENCE VECTOR
412
IR/US DETECT DECISION CONFIDENCE VECTOR
414
US DETECT DECISION CONFIDENCE VECTOR
416
DETECTION FUSION PROCESSING
418
HISTORY BUFFER
82
D
83
FEATURE STATE D'

Figure 17

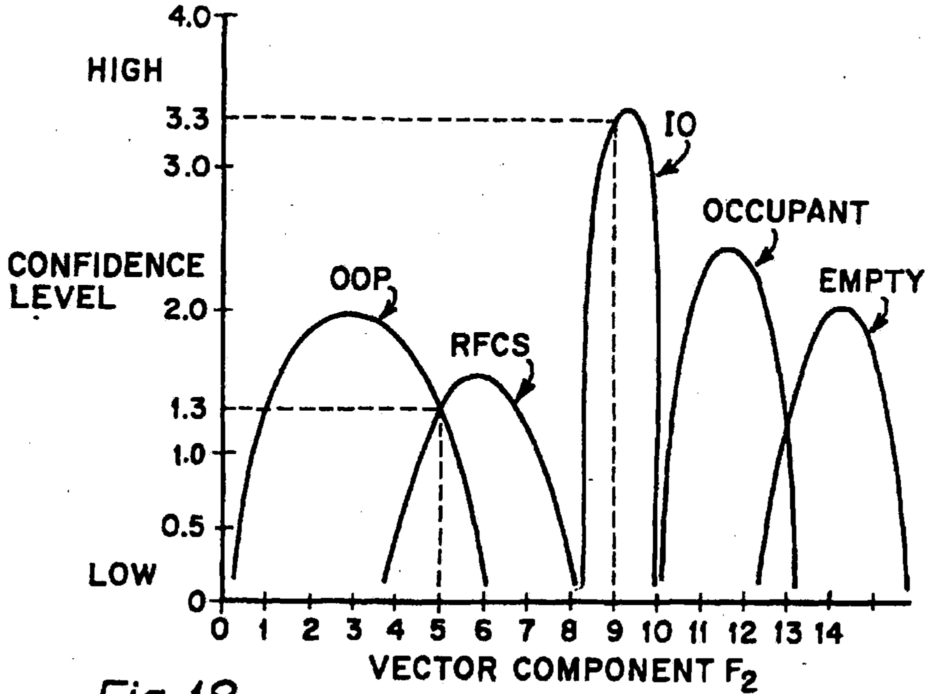

4.0
HIGH
3.3
3.0
CONFIDENCE LEVEL
2.0
1.3
1.0
0.5
LOW
0
IO
OCCUPANT
OOP
RFCS
EMPTY
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
VECTOR COMPONENT F_2

Fig_18

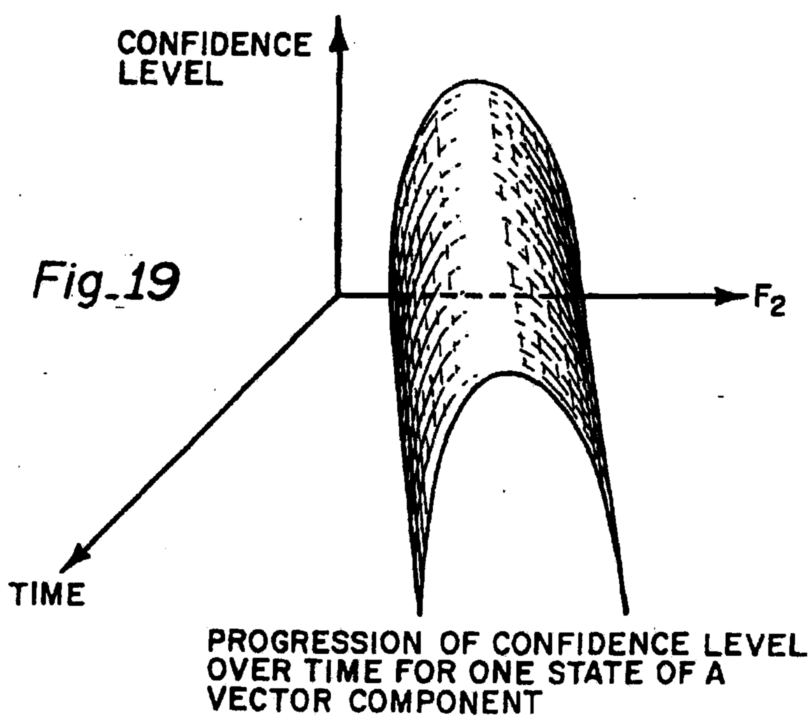

CONFIDENCE LEVEL
F_2
TIME
PROGRESSION OF CONFIDENCE LEVEL OVER TIME FOR ONE STATE OF A VECTOR COMPONENT

Fig_19

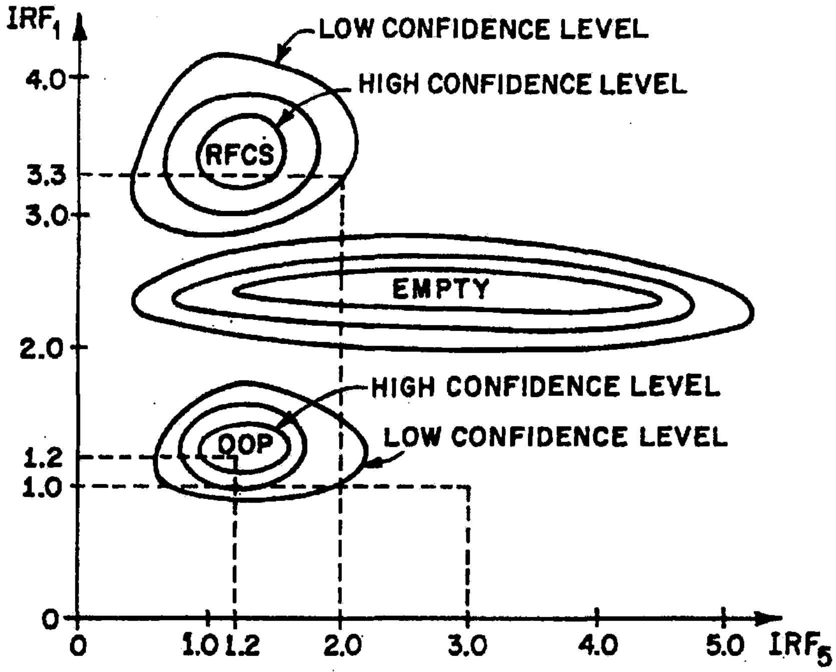


Fig_20 CONFIDENCE LEVELS FOR FEATURE VECTOR COMPONENTS

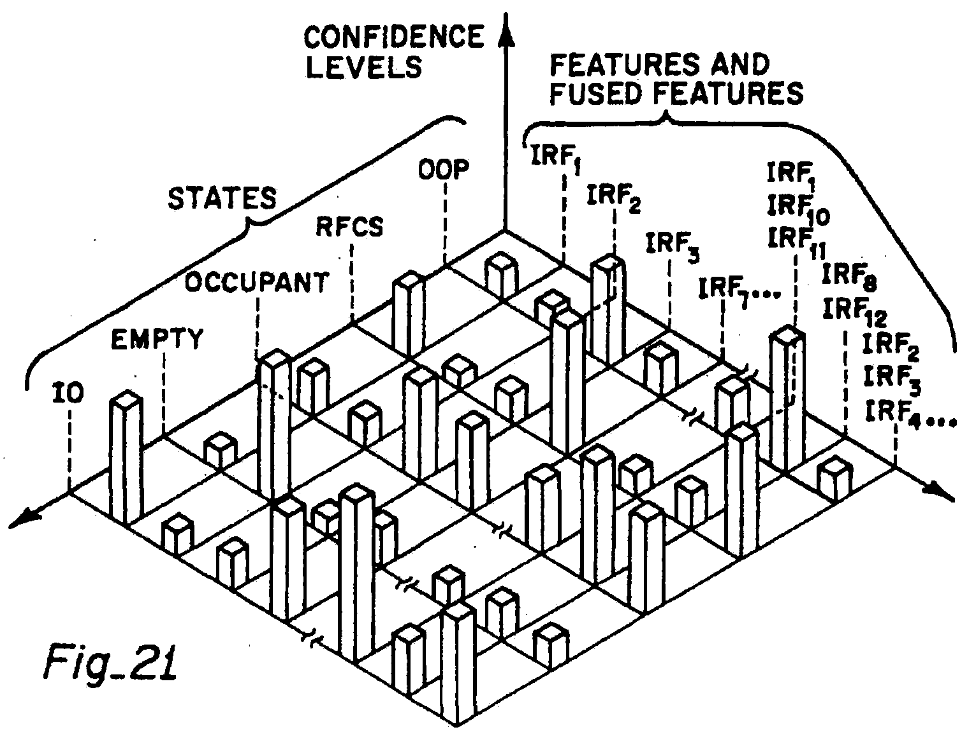


Fig_21

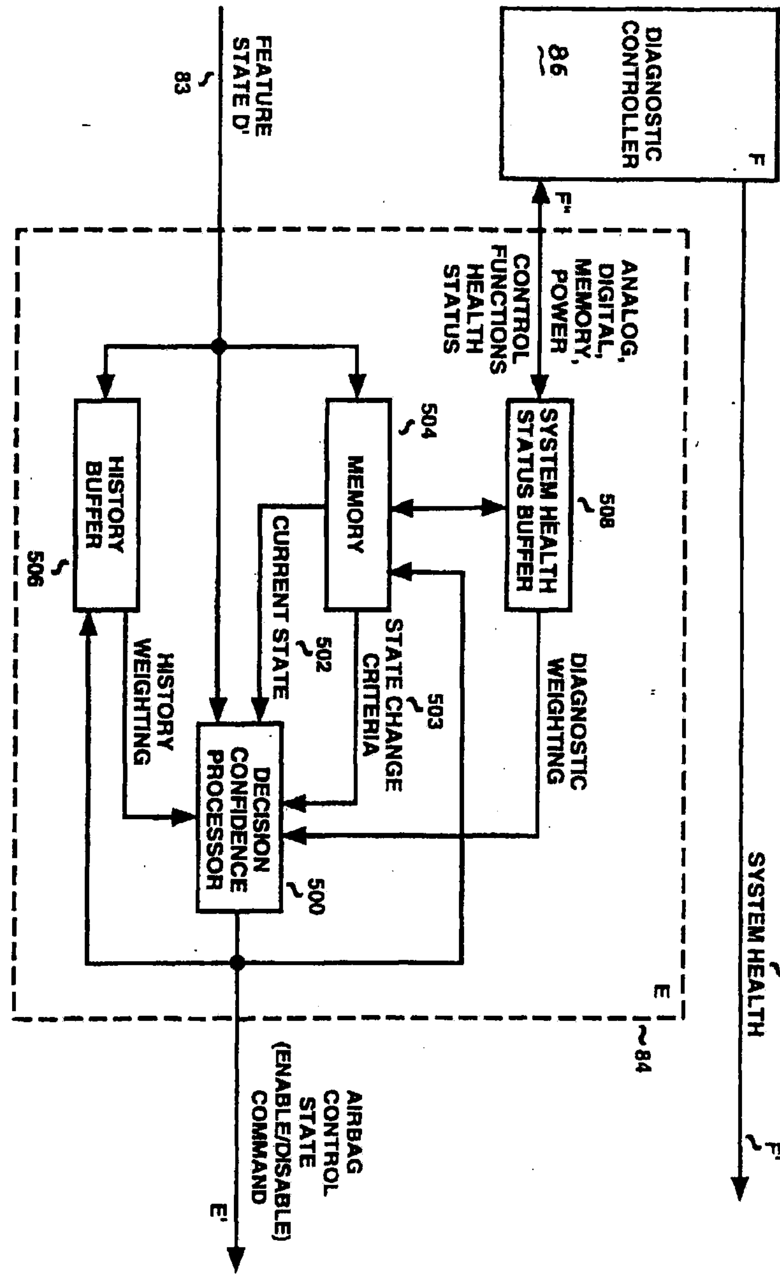
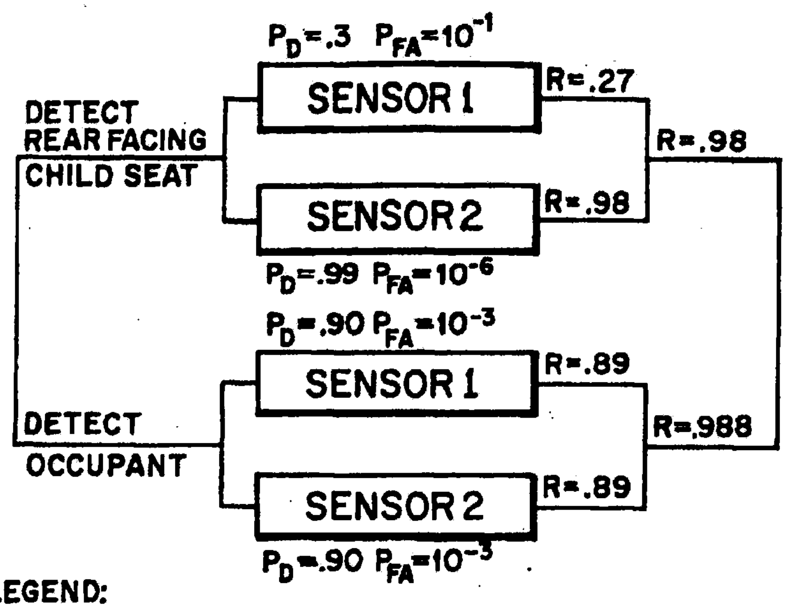

DIAGNOSTIC CONTROLLER
86
510
F
F"
F'
512
SYSTEM HEALTH
FEATURE STATE D'
83
ANALOG, DIGITAL, MEMORY, POWER CONTROL FUNCTIONS HEALTH STATUS
SYSTEM HEALTH STATUS BUFFER
508
MEMORY
504
HISTORY BUFFER
506
DIAGNOSTIC WEIGHTING
STATE CHANGE CRITERIA
503
CURRENT STATE
502
HISTORY WEIGHTING
DECISION CONFIDENCE PROCESSOR
500
E
84
AIRBAG CONTROL STATE (ENABLE/DISABLE) COMMAND
E'

Figure 22



LEGEND:

P_D = PROBABILITY OF CORRECT DETECTION

P_{FA} = PROBABILITY OF AN INCORRECT DETECTION (FALSE ALARM)

R = RELIABILITY, 1.00 = 100%

Fig_23

AOS Detection	Range	Range	R	R	Detection
Condition	Motion	Abs	Motion	Abs	Pd
RFCS	0.9959	0.9959	0.3760	0.2747	0.999992
Occupant	0.9163	0.9519	0.9959	0.7026	0.999995
Empty Seat	0.9163	0.9519	0.9959	0.7924	0.999997
RFCS under					
2 Thick Blankets	0.9591	0.9742	0.1892	0.2747	0.999379
AOS Diagnostic	R	US	ASIC	Circuit	Diagnostic
Condition	Sensor	Sensor	Circuits	Controller	Pd
Blockage	0.9742	0.9959	0.0000	0.0000	0.999894
Part Failure	0.9591	0.9591	0.9742	0.9742	0.999999
Out of Spec Part	0.9163	0.9163	0.9591	0.9519	0.999986

Fig. 26

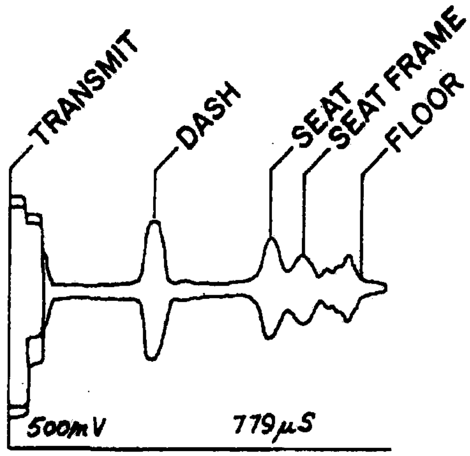


Fig_24a

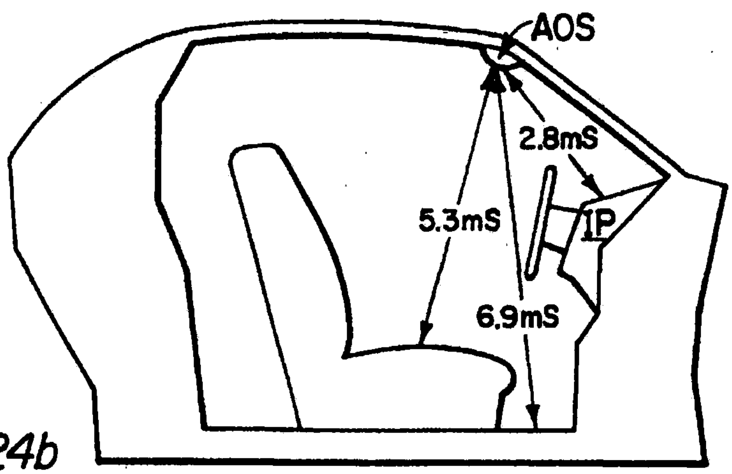


Fig_24b

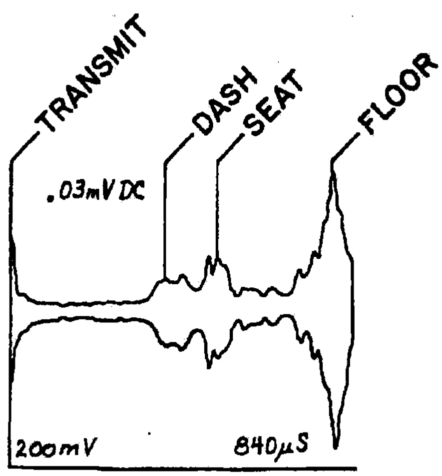


Fig_25a

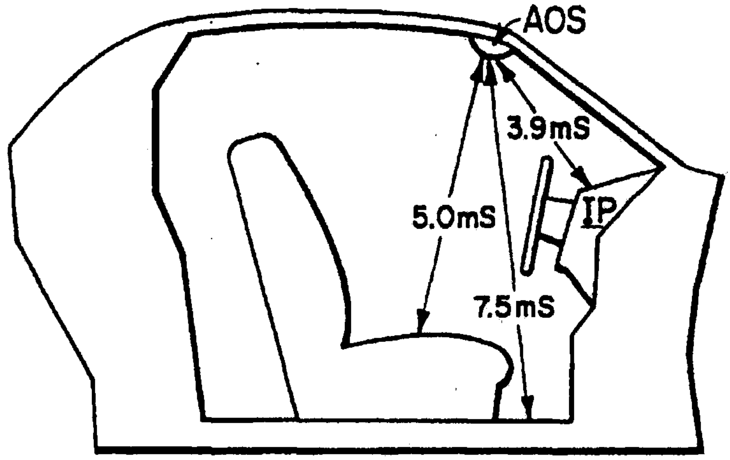
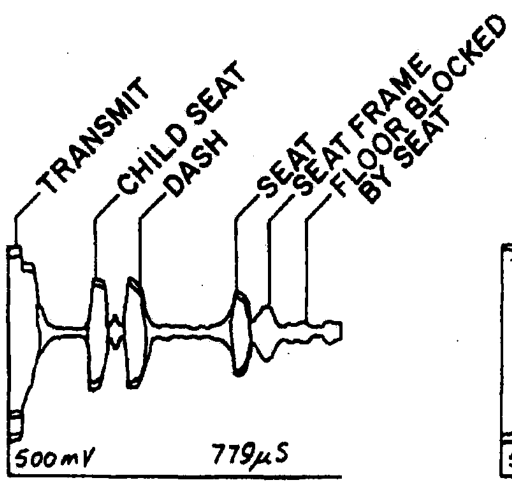
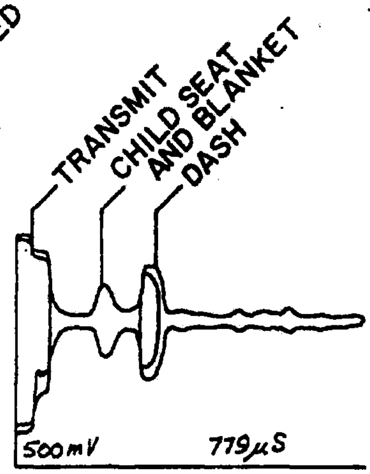


Fig_25b



VEHICLE:	93 LH
SENSOR:	P-1 OVERHEAD
STATUS:	RFCS
AIR TEMPERATURE:	22.6°C
SURFACE TEMPERATURE:	25°C

Fig_27a



VEHICLE:	93 LH
SENSOR:	P-1 OVERHEAD MOUNT
STATUS:	RFCS UNDER 2 BLANKETS
AIR TEMPERATURE:	22.6°C
SURFACE TEMPERATURE:	25°C

Fig_27b

AUTOMOTIVE OCCUPANT SENSOR SYSTEM AND METHOD OF OPERATION BY SENSOR FUSION

SPECIFICATION

1. Field

The present invention relates to sensor systems and methods of operation for use in automotive interiors to sense the presence, position and type of object in a seat and provide a condition signal for use with other automotive systems, and more particularly in conjunction with air bag activation or other type of safety restraint system for protection of passengers in the event of a collision. One embodiment of the present invention is directed to a multi-sensor occupant detection system for use in conjunction with air bag activation for determining by sensor fusion the presence or absence of a human or animal occupant, the presence and orientation of child seat (front or rear-facing), an out-of-position occupant or other types of occupancy to signal the appropriateness to deploy (or not) the air bag, thereby increasing the reliability and safety of an air bag activation system.

2. Background

Virtually all modern vehicles, autos, vans and trucks, on the American road now have air bag deployment systems. An increasing fraction of the air bag deployment systems currently available includes a passenger-side air bag as well as a driver-side air bag.

However, a passenger-side air bag deployment system presents problems in regard to criteria for deployment. That is, it is not simply an issue of always deploying a passenger air bag, as injury to occupants passengers can occur by deployment in certain situations. For example, the airbag should deploy only if a passenger is in fact occupying the passenger seat, and should not deploy when the seat is empty. However, even more importantly is the problem of deploying a passenger side air bag when there is present in the passenger seat a rear-facing child seat (RFCS), because the deployment of an air bag against the back portion of an RFCS occupied by a child can cause serious injury to the child by catapulting the child into the back of the car seat, thus defeating the safety advantages of both the air bag and the RFCS during a collision.

Accordingly, it is very important to provide a means for determining when the passenger seat is occupied and when it is not occupied. It is even more important to determine when the passenger seat is occupied by a child in a RFCS so that such information can be used to prevent deployment of the airbag when the child seat is present in that orientation. Of course, any means for determining the status of an occupant in the passenger seat, including the presence and orientation of a child seat, must be highly reliable in order to signal deployment of the air bag when the passenger seat is occupied by a passenger and prevent deployment of the air bag when the passenger seat is occupied by a child in an RFCS.

However, it is no easy task to provide a sensor system, meaning sensor units and methods of operation and signal processing, to reliably detect change of state from an empty to an occupied seat and determine the nature, position (location) and/or orientation of a passenger in the vehicle. By way of example, if a thermal sensor is used, its reliability may be reduced by thermal conditions within the vehicle which can change dramatically with the seasons, weather, vehicle interior configuration, rapidly changing exterior

shading, passenger clothing and/or size and driver's choice of interior climate, smoking, etc. Thus, a thermal sensor acting alone can lead to falsely declared occupant presence, and more importantly, failure to detect the presence of an occupant. Furthermore, there may be cases where the thermal signature of a rear-facing child seat blends so well with the seat upholstery that a thermal sensor does not see it, allowing the airbag system to deploy despite the presence of a child-occupied RFCS.

Conversely, if one were to use instead distance measurements, such as by the use of acoustic sensors, such sensor must be capable of distinguishing between the presence of an RFCS and the presence of a passenger holding an object which can result in distance measurements which mimic the presence of a rear-facing child seat.

There are other scenarios as well that require a sensor system to recognize and take appropriate action, such as a forward-facing child seat, inanimate objects, a passenger holding an inanimate object, an out-of-position passenger, and so on.

In addition to these basic sensor requirements, the system for determining the presence of a passenger in the passenger seat and the presence or absence of a rear-facing child seat, must be cost effective and must be in a sufficiently small package to prevent interference with normal vehicle operation. Such systems must be compatible with the aesthetics of the vehicle so as not to affect a vehicle's salability particularly as it relates to new passenger cars. Furthermore, the cost of installing such system in the vehicle must remain simple to keep manufacturing cost low. Preferably, all the sensors should be kept in a single unit to ease the assembly of the vehicle in production or retrofitting older vehicles.

There is no currently available sensor system known to the Applicants which can reliably distinguish the presence and absence of a passenger in the passenger seat as well as the presence or absence of a rear-facing child seat in the passenger seat.

There is also no currently available sensor system that can account for a wide variety of possible variations in both thermal and distance parameters that are encountered in the actual wide range of circumstances of occupancy, nor one that is sufficiently versatile to be adaptable to the wide range of vehicle interior configurations.

An example of a system for actuating a driver airbag restraint is shown in White et al U.S. Pat. No. 5,071,160 (Automotive Systems Laboratory) which employs an ultrasonic acoustic sensor for sensing the position of the driver, a "pyrotechnic" sensor for sensing the presence of the driver, and a pressure transducer within the seat to sense the approximate weight of the driver and an airbag control module to trigger deployment of the airbag. As best understood, when an impending crash is sensed by a crash sensor, a control module samples the sensed position of the passenger at fixed time intervals to calculate the rate of movement of the passenger relative to the various fixed motion structures of the vehicle. This rate of relative passenger movement is used to corroborate the acceleration data from the crash sensor and ensure deployment of the airbag where the passenger is at substantial risk of injury. That is, the interior passenger acceleration is apparently used to prevent false crash signals from the crash sensor. Early crash sensors may trigger airbag deployment during a minor bump in close slow moving traffic or during parking. This " is-the-passenger-being-accelerated-at-the-same-time" system is directed to correcting false signals from the crash sensor.

The patent describes the desired results but does not detail the process or circuitry to achieve these results beyond stating that the airbag control circuit uses error correction methods such as a plurality of each type of sensors (crash sensor, pyrotechnic, ultrasonic, acoustic, and pressure transducer) for each assigned monitoring task to prevent falsing. Accordingly, the control circuit is said to employ redundant sensors for each monitoring task and the instructions executed by the control module are said to include error correction subroutines known to one skilled in the art. A dashboard signal lamp can be lit when the airbag effectiveness is too low, or the likelihood of passenger injury by the airbag is greater than the injury if he hit the steering wheel, dash or knee bolster, the latter being consistent with the slow bump situation described above.

Accordingly, there is a need in the art for a reliable occupant sensor system for use in conjunction with vehicle air bag deployment systems. There is also a need for a sensor system that can meet the aforementioned requirements for reliability in detecting the presence or absence of a passenger or RFCS in a wide range of circumstances, irrespective of whether a passenger is holding an object and irrespective of the thermal conditions that may be found in the vehicle. Such a sensor system must also be a cost effective component of the vehicle that does not detract from the aesthetics of the vehicle interior or unduly increase the cost of manufacturing or assembling a vehicle.

THE INVENTION

OBJECTS

It is an object of the present invention to provide an automotive occupancy sensor system to reliably detect the presence or absence of a passenger in the passenger seat and the presence or absence of a rear-facing child seat in the passenger seat and to provide a signal to the airbag system to either inhibit or permit the deployment of a passenger side air bag during a collision.

It is another object of the invention to provide a vehicle passenger sensing system which relies upon multiple sensors utilizing different physical phenomena to provide signals which are processed by sensor fusion to significantly enhance the reliability of passenger detection while permitting the use of relatively low cost conventional sensors.

It is another object of the invention to provide a vehicle occupancy sensing system adapted for use with a passenger seat of a vehicle to control the deployment of an air bag, and specifically to inhibit the deployment of an air bag when a passenger seat is unoccupied, or occupied by inanimate objects, or the occupant is out-of-position, and when an RFCS is present in the passenger seat, in order to prevent unneeded deployment or unsafe deployment which might otherwise cause injury.

It is another object of the invention to provide a passenger occupancy sensor system which utilizes both thermal and acoustic sensors, the signals from which are processed in a fusing algorithm to produce an output signal permitting deployment of a passenger side air bag only when the passenger seat is occupied by a passenger properly positioned in the seat and inhibiting deployment of an air bag in other preselected conditions of occupancy.

It is another object of the invention to provide a multiple sensor occupancy detection system which processes by sensor fusion certain preselected features extracted from signals provided by different certain sensors which sense different physical parameters to increase the reliability of the individual sensing characteristics of the individual sensors.

It is another object of the invention to provide a multiple sensor occupancy detection system while maintaining low cost in manufacturing of the vehicle by locating sensors in a single unit to ease the task of mounting the sensor system to the vehicle.

It is another object of the present invention to provide a multiple sensor occupancy detection system while maintaining aesthetics of the vehicle by producing a sensor system of minimal size.

It is another object of the invention to provide a sensor system that can be tuned to individual vehicle interior configurations with unparalleled precision of discrimination by sensor fusion signal processing to produce state, condition or decision signals that may be used as input to a wide variety of automotive systems, including but not limited to occupant safety, vehicle integrity and safety, vehicle operating systems condition or position (e.g. seat position and load adjusting systems), unusual conditions, interior temperature control, unauthorized entry (Passive Theft Detergency), near object detection systems, and the like.

Still other objects will be evident from a review of the Summary, Drawings, Detailed Description and claims hereof.

BRIEF DESCRIPTION OF DRAWINGS:

The invention will be more fully understood hereinafter by reference to the drawings in which:

FIGS. 1–8 show various conditions illustrative of the variety and range of real conditions that must be detected and accurately discriminated-amongst by a fully-functional automotive occupant sensor system which, by way of example, is focused on a passenger seat of a vehicle, with: FIG. 1 showing the seat being occupied by a passenger; FIG. 2 showing the passenger seat unoccupied and sensed as "empty"; FIG. 3 showing a child in a rear-facing child seat ("RFCS"); FIG. 4 showing a passenger holding a bag of groceries; FIG. 5 showing a child in a forward-facing child seat ("FFCS"); FIG. 6 showing a dog in the seat; FIG. 7 showing an out-of-position passenger ("OOP"); and FIG. 8 showing a moderate sized package on the seat;

FIG. 9A is an enlarged front view of the sensor taken along line 9—9 of FIG. 2 having an infrared sensor and an ultrasound sensor contained in a single unit, and illustrating a multi-element Fresnel lens system over a dual-detector infrared sensor;

FIG. 9*b* is a longitudinal section view of the IR sensor taken along line 9B—9B of FIG. 9A;

FIG. 9C is a transverse section view of the IR sensor taken along line 9C—9C of FIG. 9A;

FIG. 10 is a view of the passenger seat and the sensor unit in relative relationship, illustrating the infrared detector zoning of the seat and seat back areas as sensed through the Fresnel lens;

FIG. 11*a* is a side view illustrating the infrared detectors fields of view coverage on the passenger seat;

FIG. 11*b* is a side view illustrating a typical ultrasound transducer field of view coverage on the passenger seat;

FIG. 12 is a schematic diagram of the electronic circuit of an embodiment of the sensor system of the present invention;

FIG. 13 is a functional block diagram of an application specific integrated chip ("ASIC") means for carrying out the sensor fusion methods of the present invention;

FIG. 14 is a signal processor functional block diagram illustrating the processing steps used in the operation of the presently preferred best mode embodiment of the sensor system of the present invention;

FIG. 15*a* and 15*b* are feature processing block diagrams showing the steps of processing raw data from the sensors to produce infrared (FIG. 15*a*) and ultrasound (FIG. 15*b*) feature vectors;

FIG. 16 is a fused feature processing block diagram illustrating the process of fusing infrared features and ultrasound features to produce a fused feature vector;

FIG. 17 is a detection processing block diagram showing the processing of the infrared feature vector, ultrasound feature vector, and fused feature vector to produce a feature state;

FIG. 18 is a graph illustrating the relationship between a feature vector component and confidence levels of various occupancy states by way of example: OOP state, RFCS state, inanimate object state, occupant'state, and empty state;

FIG. 19 is a graph illustrating the progression of confidence levels for a given state and a given feature vector component over time;

FIG. 20 is a graph showing confidence level upon fusion of two feature vector components;

FIG. 21 is a graphically illustrated matrix of the relationship between vector components, and fused vector components, states, and confidence levels; and

FIG. 22 is decision processing block diagram illustrating factors considered in a state change decision process.

FIG. 23 is a diagram of sensor decision reliability in a case of discriminating between a normal occupant and an RFCS;

FIG. 24*a* shows a signature trace from an automobile;

FIG. 24*b* shows the physical layout of the vehicle giving the trace of FIG. 24*a;*

FIG. 25*a* shows a signature trace from a truck;

FIG. 25*b* shows the physical layout of the vehicle giving the trace of FIG. 25*a;*

FIG. 26 is a table of test data from actual testing of a sensor system of the invention; and

FIGS. 27*a* and 27*b* are comparative traces showing sensibility of the discrimination between an RFCS and the same RFCS covered with two blankets.

SUMMARY

The present invention is directed to an automotive interior occupant sensor system employing sensor-fusion signal processing which combines information provided by two or more sensors, each of which "sees" the world in an unique sense. The multi-sensor fusing process of this invention greatly enhances performance and reliability in much the same way as human ability to visually distinguish and classify objects is greatly enhanced with the addition of sound. While the invention is described in detail with respect to sensing the presence (or absence) of a variety of seat occupants for the purpose of sending a signal to an airbag deployment system thus enabling or disenabling the airbag system to permit or prevent deployment in preselected situations, the "decision" or state signal produced by the sensor system apparatus and sensor signal fusion method of this invention may be applied to also, or alternately, check, affect or trigger other systems, such as automatic safety belts, seat positioning systems, interior climate controls, lighting, dashboard or other signal or warning lights, audio alert or status signals (buzzers, recordings, or synthesized voices), door locks, load adjusting systems, reminder systems crash conditions recording systems, and the like.

In a preferred embodiment, the automobile passenger seat occupancy sensor of the present invention relies on two detectable properties: One such property is the thermal signature and associated motion, and the second is the acoustic distance and the associated acoustic motion. By relying on two distinct sensors in which a plurality of independent features (or characteristics) are extracted and fusing some of these features, the accuracy and reliability of sensing is vastly improved as compared to single sensor or even multiple sensors not employing sensor fusion. For example, in cases where the thermal signature of a rear-facing child seat blends with seat upholstery and provides no motion signal, the distance measurement may be able to detect that something is in the seat with suitable reliability. However, in cases where passengers are holding objects or are much larger than normal, an ultrasonic sensor will provide ambiguous distance measurements which "look" like an RFCS. By the fusion method of this invention, combining features extracted from IR detectors angled and zoned to "look" at different fields and from an ultrasound sensor can ensure proper identification and output of an appropriate decision signal.

In accord with the present invention, measurements of conditions are taken continuously and compared to prior conditions to provide a current state profile. At least initially, the updates are compared to initial conditions obtained at the start-up of the vehicle, and later the comparison is with prior state conditions. If initial conditions indicate a recognized (or "valid") occupant, this condition will tend to prevail throughout operation of the vehicle with the sensor algorithm always erring on the side of safety. If initial conditions indicate an empty seat, a "wake up" mode ensures that passengers changing seats during vehicle operation are detected. A standby mode while ignition is off may be provided in order to draw less power and perform only the minimum required periodic checks and maintenance functions.

Individual sensors will make incorrect decisions by themselves under certain conditions but in unrelated, non-overlapping ways. The fused sensor approach of the present invention covers these failure modes to assure reliable performance by requiring analysis of many different signal features before making a recognition decision. Ordinarily, to compensate for its own area of marginal performance, an individual sensor must become more and more sophisticated, driving up costs. In contrast, the system of the present invention employs fused data from two or more inexpensive sensors, thus achieving the required sophistication level, yet at a significantly reduced cost. Further, in dual sensor operation, self-diagnosis is enhanced by correlating data in one sensor with data from the other.

Although the preferred embodiment of the present invention utilizes passive thermal and active acoustic sensing for their inherent design, simplicity, and safety features, it will be understood that the present invention is not necessarily limited to the use of multiple sensors of the particular type disclosed. While the selected sensors are non-radiative and present no electromagnetic, electro-optic exposure or other exposure hazards to the occupants, it will be understood that other combinations of two or more sensors of different types for occupancy sensing can be readily used to achieve the simplicity and yet high reliability, of the present invention by the sensor fusion method of the present invention. In any

case, the sensors disclosed herein do not present any exposure hazards to occupants; for example the ultrasonic unit operates at a frequency well above the hearing range of humans and dogs.

It should be understood that the present invention is not necessarily limited to use in conjunction with an air bag system. It can also be used for security and safety purposes because the combination of two distinct sensor characteristics such as the combination of thermal contrast and motion with acoustic distance and motion as shown herein, prove highly advantageous for its reliability and simplicity in a number of applications outside a vehicle as well as other applications with a vehicle. It may be used as a security system for the premise of a piece of property, both inside of a building as well as outside of the building.

In the preferred embodiment of the invention, infrared sensor inputs and an ultrasonic sensor input are combined in a microprocessor circuit by means of a sensor fusion algorithm to produce an output signal to the air bag controller. The signal results from preselected confidence weighting for the various parameters extracted from the two sensors (called features), and upon a fusion process which ultimately makes a decision which is extremely reliable. An empirical profile, in the form of a lookup table, matrix of values, or empirical relationships, or algorithm is provided for a plurality of known objects (e.g. human occupant, empty seat, rear and forward facing child seat, animal, packages, etc.) either as a generic interior profile or as developed (empirically determined) for a particular interior. During operation the fusion processing compares the signals to a matrix of known condition confidence values to produce a set of confidence weighted values. By way of example, some 14 selected IR features and 13 selected ultrasound features are compared either directly or after fusion to arrive at an overall confidence level that results in triggering the enable/disenable signal (or absence of signal) to the airbag deployment system. The output signals are compatible with AECM interfaces.

The IR sensor unit advantageously includes dual detection elements that look at different areas of the seat, e.g. the seat back and the seat itself. In addition, the "view" of these sensor elements are zoned into vertically oriented parallel zones by means of one or more Fresnel type lenses so that "thermal motion" features can be extracted from the change in thermal signatures from zone to zone.

The occupant sensor algorithm performs the sensor fusion matrix processing and decision making operation on the selected sensor outputs. The fusion matrix has inputs weighted to guarantee reliability in the decision making process. All sensor outputs along with empirical "known" condition data, calibration data, initial conditions and updated historical reference data are considered in the process of making a decision (outputting an enable or disenable signal) whether or not to suppress the deployment of the passenger-side air bag in a collision. By fusing the features and feature vectors to make the decision, each individual parameter has only a partial effect, or "vote", on the ultimate fusion decision. The final decision is based on several conditions or states reinforcing that decision by requiring several independent phenomena or aspects thereof to occur simultaneously.

The fusion process of the invention produces decision with a higher reliability than a single phenomena sensor or non-fused multiple sensors. In addition to performing the multi-sensor fusion decision making, the process requires periodic analysis of the sensor outputs to make certain that all sensors are functioning properly. In addition to normal electrical condition checks, conditions from each sensor output are compared with the output from the other sensor to be sure that all sensors confirm proper operation. In the unlikely scenario where the sensor system fails entirely due to power failure, component failure, or otherwise, the air bag deployment system controller defaults to deployment condition to ensure passenger safety. A diagnostic warning indicator of a failure condition may be provided to the vehicle's indicator panel.

All the sensors of the present invention can be provided in a single unit to maintain low manufacturing cost and simplify the task of assembling the sensor system to a new vehicle or retrofit it to a previously-assembled vehicle. In addition, the aesthetics of the vehicle is maintained by keeping the sensor system unit to a minimal size.

Having two or more sensors in the fusion mode enhances self-diagnostic correlation between the two, for if there is a failure of one but not the other, even in scenarios where no or little signal is expected from the failed sensor, still some of the expected features will be missing and analysis and fusion will identify the failed sensor. For example, if US indicates an occupant, the IR can be polled. If it indicates no occupant, then a potential sensor malfunction is indicated. If there are some features from the IR, say weak signal IR, then the IR may be working but it is not clear what is in the seat until other polled features are analyzed by the fusion process algorithm of the invention.

While a fixed sensor system with angled lenses (for the IR) are shown, a mechanical sweep scan can be employed by mounting one or more sensors on a moving element. Likewise while a fixed US transducer and receiver is shown using pulsing to toggle or poll the sensor, a separate transducer and receiver may be employed. The acoustic signal profile may be shaped to the interior for maximum or narrowly focused coverage in a specific area.

The IR sensor may be an uncooled electric device that responds to IR radiation from the near to far IR (2–12 micrometers wavelength), and the US may be an electrostatic type sensor with a typical frequency range of 40 KHz to 150 KHz. The typical field of view will be approximately 30°×34° for the IR, and 20° to 30° (conical direct or offset) for the US. The US is highly immune to interference because the pulse echo must be received within a preselected time window to be valid. The US beam may be asymmetric for better coverage. A separate IR sensor can be added to the unit oriented to look at the center (middle) passenger location.

Without additional hardware the system of the invention can automatically cycle "on" to measure the interior temperature of the vehicle in which it is installed and send a signal to automatically adjust or cause the cooling fan to operate whenever the interior temperature exceeds a preselected (design selected) maximum value. Additionally, the system can automatically, at "power up", measure the characteristic interior "signature" of the particular vehicle in which it is installed, and by comparing these values to predetermined reference tables imbedded in the ASIC, determine which type of platform it is installed in, e.g., auto or truck. It can then transmit the vehicle identification type to the body controller thus automatically verifying correct and proper functioning at the final installation/assembly point.

The ASIC of this invention permits several additional features to be optionally incorporated into the sensor system of this invention as desired. These include: 1) Center Passenger Occupant Detection (CPOD) employing an additional IR sensor and lens to detect center seat occupancy. 2) Four Quadrant Temperature Control (FQTC). This system

replaces presently used sun sensor and environmental control unit. It not only controls the vehicular interior temperature, but also enables automatic selection and control from one to four quadrants of directed HVAC (permitting up to four individual interior temperature settings). 3) Passive Theft Detergency (PTD). The automatic temperature control sensors can be used to detect the presence of a person in the vehicle and through communication with the body controller can decide if entry was proper or not, i.e. was a key used to gain entry (proper) or not (improper entry). 4) Near Object Detection Sensors (NODS). This system utilizes an extremely low power microwave radar which mounted behind a plastic cover (taillight or bumper), and tailored to detect objects within a preselected field-of-view.

The FQTC is similar to the occupant sensor, and uses a "multi-apertured" lens to facilitate motion detection. Further, the sensors are effectively "multiplexed" into the central network processor where sample timing, duty cycle, and sensor select sequence are all programmable.

PTD employs thermistor bolometer (TB) detectors, instead of pyro-electrics, and is thus capable of sensing both the motion of a warm object as well as being able to determine its approximate temperature. This PTD implementation is electronically configured to provide continuous or selected intermittent vehicle monitoring. The electronics (Signal Conditioner, Power Regulator, Motion Sense Logic, etc.) are configured for extremely low (less than 100 microamps) current drain on the vehicle's battery during security "system on" status, such as when the vehicle is unattended with the ignition off. This configuration permits active temperature monitoring of each zone while the automobile is in use. Further, when the vehicle is left unattended, the sensor suite is capable of detecting and reporting unwanted intrusion associated with vehicular theft or possibly a person hiding in the rear seat area.

NODS utilizes microwave (impulse) radar rather than the classical IR and Acoustic sensing, but employs sensor fusion as disclosed herein. Microwave radar is employed due to its ability to operate (invisibly) while protected from an exterior hostile environment by mounting it in a bumper or tail light assembly location. This system possesses a reliable range detection of on the order of 15+ feet. The hardware concept incorporates voltage protection, J1850 Bus interfacing and one or more ASIC(s) for control and algorithm implementation in accord with the principles of the invention. The specific frequency employed is in the range of from about 1.7 to 94 GHz.

The sensor system and methods of the invention key on the following properties: Thermal signatures or contrasts coupled with motion to establish the presence of a warm object; and Acoustic signatures via wave propagation coupled with motion to establish object status, i.e. the distance from dashboard or headliner location of occupants, objects, empty seat, etc. and if animated or stationary.

Both sensor properties are required to meet the reliability requirements because: 1) The need to inhibit the airbag when a rear-facing child seat is more reliably accomplished through dimensional measurements; these are more reliably derived from the acoustic sensor. 2) Thermal conditions within a vehicle change dramatically with seasons, weather, vehicle interior, passenger clothing, and driver use. Using an IR sensor only may lead to higher rate of falsely-declared seat status condition and, more importantly, the failure to detect an occupant present. 3) The self diagnostic capability of the system requires sensor interaction/confirmation to enhance it's reliability.

The signal processing employed in the multi-sensor fusion of this invention is preferably implemented in an Application Specific Integrated Circuit (ASIC). In addition to the signal processor ASIC, a micro-controller provides additional decision making power and system control functions. The ASIC is a mixed signal analog and digital device. It performs signal conditioning, sensor signal detection, non-volatile storage, bus interface, status signal interface, and clock generation functions. The confidence weighting and fusion matrix parameter processing is conveniently performed in software running on the micro-controller or can be implemented using hard-wired logic circuitry. The software can be implemented by one skilled in the art following the Figures as described in detail herein.

DETAILED DESCRIPTION OF THE BEST MODE

The following detailed description illustrates the invention by way of example, not by way of limitation of the principles of the invention. This description will clearly enable one skilled in the art to make and use the invention, and describes several embodiments, adaptations, variations, alternatives and uses of the invention, including what we presently believe is the best mode of carrying out the invention.

Referring now to the accompanying drawings, FIGS. 1 through 7 illustrate a variety of occupancy scenarios to which the present invention is generally directed in its preferred automotive occupancy sensing embodiment. As shown in FIG. 1, this embodiment of the invention comprises a sensor suite 1 mounted in the overhead area above and slightly to the center of the passenger seat 12 of the vehicle 14. As described in more detail below, the microprocessor controller, including an ASIC having the firmware described herein is conveniently located in the sensor unit assembly 1 mounted in the headliner 16 or dash 28. The sensor unit 1 is connected to a conventional airbag controller 2, which in turn activates an airbag 4 in an appropriate crash-sensed situation. The system is conveniently powered by the auto battery 6, or alternately by the alternator or a separate trickle-charged gell cell (not shown).

Various possible scenarios are represented by way of example in the following figures. FIG. 1 depicts the passenger seat 12 occupied by an average adult person 8, while FIG. 2 depicts an empty seat. FIG. 3 depicts the presence of a child 10 in a rear-facing child seat (RFCS) 11 mounted on the passenger seat 12. The RCFS will have an unusual thermal pattern as well as distance and vibration signatures due to the possibility that the child may in part be obscured by the seat, thus masking natural thermal radiation. FIG. 4 depicts an adult person holding a bag of groceries 18, which will also have unusual sensor readings. FIG. 5 shows the presence of a child 10 in a forward-facing child seat (FFCS) 20. Unlike the RFCS, this FFCS scenario will have a more nearly normal thermal signature for a small child as well as normal motion and distance readings. FIG. 6 shows the presence of a pet such as a dog 13. Depending on the size and activity of the pet, there will be variation in the thermal, motion, and distance readings and the rate of change thereof. FIG. 7 depicts an illustrative out-of-position (OOP) passenger scenario, where a child 10 is standing up on the passenger seat and holding onto or leaning against the dash board. It could also be a passenger adjusting the radio, or looking out of the front windshield or with his legs or feet up on the dash. In this scenario, the sensor system needs to determine the feasibility of deploying the air bag which

depends on the distance of the passenger to the location of the air bag. If the passenger is too close to the air bag location, air bag deployment may not serve any useful purpose, and indeed, might injure the occupant in the process.

It should be noted that in certain scenarios, the location of the sensors unit in the headliner is an advantage. Comparing for example, FIGS. 3 and 7, if the sensors are located at position X and/or Y as compared to the more universal, wide-angled headliner position 16, the RFCS 11 or OOP occupant 15 may obscure or overload one or more of the sensors by coming in contact with the sensor unit face.

The seat may also be occupied by passengers of different size, such as a small child or a larger person. An occupant may be reclined in the passenger seat or sleeping in the passenger seat without giving off much movement, and both cases will have unusual motion, distance, and thermal signature. Referring to FIG. 8, there may be inanimate objects 17 of various size on the seat which may or may not give off thermal and/or motion signatures.

In addition to these scenarios, the weather and shading conditions may affect the interior environment of the vehicle, especially the interior temperature of the vehicle. On a hot summer day, the passenger seat will be extremely hot after the vehicle has been sitting closed in the sun, and this condition can affect sensor readings. In addition, driving along a tree lined highway can lead to thermal flicker, which could mimic a motion signature, due to intermittent shading and exposure of the seat. The present invention is not limited to the detection of the above-discussed scenarios, as others can be detected as well.

Given this wide variety of occupant and external and internal conditions, the present invention must be able to detect, discriminate and make a decision to permit transmission of an air bag enable signal, or generate a disenable signal to the air bag controller to maximize passenger safety in the event of a collision. In the preferred embodiment of the present invention, these scenarios are categorized into one of the following five states: Empty state, Occupant state, Inanimate Object ("IO") state, Rear-Facing Child Seat ("RFCS") state, and Occupant Out-Of-Position ("OOP") state. For the detected Empty state, IO state, RFCS state, and OOP state, an air bag disenable signal will be sent or supplied to the air bag controller. For the Occupant state, an enable air bag signal will be supplied to the air bag controller or, in the event that the default condition of the air bag controller is to signal the air bag to deploy, no interrupt signal will be sent from the sensor unit to the air bag controller (or air bag). Other embodiments may include more or less states with variation in the scenarios.

The Occupant state is the state where air bag deployment will enhance the safety of a passenger in case of an accident. The Occupant state includes the scenarios of an average adult person, a small child, a child in a forward facing child seat, a passenger holding a bag of groceries, a standing child in some positions, and the like. Note that in the standing child scenario, the air bag will be deployed if the child is sufficiently far away from the air bag deployment location to allow an effective and non-injurious deployment of the air bag. The air bag will not be deployed if the child is too close to the air bag deployment location, since deployment of the air bag might injure the child by knocking it back into the seat. The same consideration applies to the OOP state, a passenger positioned too close to an air bag can be sensed to prevent an injuring deployment.

Typically, it is desirable to disenable the air bag in the RFCS state, the Empty state, the OOP state, and the IO state, e.g. by sending an interrupt signal or interrupting the deploy signal from the airbag controller. It is especially important in the RFCS scenario that the air bag is not deployed in case of an accident. A deploying air bag striking the back of a rear facing child seat could catapult the child and seat backward, possibly injuring the child in the process. In the case of an Empty state or IO state, deploying the air bag in case of an accident ordinarily does not serve any useful purpose, and only adds to the repair cost of re-installing a new air bag in the vehicle. However, the system of the invention is biased toward deployment to ensure the highest level of safety and reliability.

In the preferred embodiment of the invention, the air bag controller is designed to default to the air bag deployment condition. For the appropriate states, such as the Empty state, the IO state, the RFCS state, and the OOP state, the sensor system sends a disenable or interrupt signal to the air bag controller. The present invention is also adaptable for use with a multi-canister controlled pressure air bag deployment system where the air bag is inflated by a number of canisters to the desired pressure. With this system, instead of sending an "on" or "off" type of signal, a quantitative serial, or multiple parallel type of signal can be transmitted to the air bag controller to indicate the desired pressure, or the number of canisters to release depending on the sensed state.

In order to recognize the various scenarios and conditions, this embodiment utilizes two sensors, an infrared ("IR") sensor and an ultrasound ("US") sensor. The infrared sensor used in this embodiment is a commercially available thermistor type of infrared sensor unit, and there are preferably two or more detector elements contained within the infrared sensor unit to allow sensor detection in or from two different regions. Although pyro-electric and photovoltaic types of infrared sensors may be used as well, the thermistor type of sensor presently provides the best cost/performance ratio. In the presently preferred embodiment, the infrared detectors sense the targeted areas continuously with an interrogation period of between about 2 Hz and 10 Hz.

The ultrasound sensor used in this embodiment is a commercially available ultrasound sensor circuit package where the ultrasound frequency and pulse can be externally controlled. The sensor operates in the ultrasonic range above the hearing range of humans and animals such as dogs, and the typical frequency ranges are from 40 KHz to 150 KHz. Frequency selection is determined by requirements such as acoustic losses, range, power, cost, and transducer size. For example, air attenuation and absorption by seats and clothing are increased with frequency; however, the required sensing range here is short, and as a result, the higher end of the frequency range can be selected. The higher frequency also provides the advantage that a small transducer head (sensing element) can be used. In the presently preferred embodiment, the interrogation period varies between 2 Hz and 20 Hz during actual operation depending on the amount or quality of information needed.

FIGS. 9A–9C are enlarged views of the sensor unit of the present invention shown in place in headliner 16 of FIG. 1. The sensors may be placed separately at different locations, but in the preferred embodiment, as shown in FIG. 9A, the infrared sensor 24 and the ultrasound sensor 26 are placed next to each other in a single unit 22. The infrared sensor preferably has two or more detectors 21*a*, 21*b* separated by a vertical baffle 19 and covered by a multi-element Fresnel lens 23. Each detector 21*a* (D-1) and 21*b* (D2) view different positions of the seat, 21*a* looking at seat back area 12*b*, and

21*b* looking at seat area **12*a*** (see FIG. **10**) through, in this example two rows of Fresnel lens elements, Fla and Flb, which form a lens set Ls-1 and Ls-2 respectively. Each row in this example has six individual lens elements **50*a***, **50*b*** . . . **50*n***, which look at the corresponding zones **50*a***, **50*b*** . . . **50*n*** on the seat as seen in FIG. **10**. The fields of view of the lens row Fla overlaps the row Flb, but the individual zones **50*a*** in **50*n*** do not overlap. The baffle **19** is generally aimed at the seat belt when worn properly by the passenger, as shown by arrow Q in FIG. **9B**.

FIG. 9B is a longitudinal schematic cross section of the IR sensor **24** along line **9B**—**9B** in FIG. **9A** showing its orientation with respect to the horizontal in the headliner **16**. While the angle θ can be 0° it preferably ranges from about 5°–45° with 10°–30° being preferred. FIG. **9C** is a transverse section view of IR **24** taken along line **9C**—**9C** of FIG. **9A**. It shows the generally faceted orientation of the zones of Fresnel lens elements **50*a*** . . . **50*b***. In the alternative, the elements may be stepped with respect to each other.

The Fresnel lens allows the signal strength of a signal source from the middle of the zones to fully pass through. However, as the signal source moves toward the edges of the zones, the Fresnel lens proportionally reduces the strength of the signal passing through.

Although these sensor units can be placed in a number of places in the vehicle, it is preferred to be placed in the headliner **16** above the passenger seat as seen in FIG. **1**. The sensor unit can also be placed on the dash board directly in front of the passenger seat or on the passenger side A-pillar. It is anticipated that in the future rear passenger seats may be equipped with air bag protection as well. In this case, a sensor unit placed forward and above the targeted passenger seat in the headliner or in the B pillar can be used to sense rear seat occupancy.

FIG. **10** is a top view of the passenger seat **12** and the sensor unit **1**. The passenger seat has a back area **12*b*** and a seat area **12*a***. Each area (back and seat) is sensed in multiple zones **50*a***, **50*b*** . . . **50*n*** created by the Fresnel lens elements of the infrared sensor as shown in FIGS. **9A**–**9C**. Note that the infrared sensor uses a Fresnel lens of the type in which each of the infrared detector field of view is divided into, for example, five to eight zones. The infrared detector converts photons (heat) into a change in conductance of the detector which results in a sinusoidal wave voltage when an object laterally crosses each zone.

FIG. **11*a*** illustrates a side view of the orientation of the two detectors **21*a***, **21*b*** (FIG. **9**) of the infrared sensor, looking at the passenger seat **12**. One detector **21*b*** is oriented to view the seating area **12*a*** while the other detector **21*a*** views the back **12*b*** of the seat. In addition to receiving zoned thermal signature data, each infrared detector senses lateral motion of the occupant or object crossing the zones **50*a*** . . . **50*n*** in its designated area **12*a*** or **12*b*** of the passenger seat. By combining data from the two infrared detectors, "longitudinal" motion of the passenger can be determined as well. By "longitudinal" motion is meant motion by a passenger (e.g. a passenger's hand) that crosses from the area detected by one detector to the area detected by the other detector, and includes both fore/aft or front/back (with respect to the vehicle) motion and vertical or up/down motion, or compound motion having both fore/aft and vertical components. FIG. **11*b*** depicts the area scanned by the ultrasound sensor **26** when aimed at the seat, and portions of the floor and dash **28**.

Referring now to the hardware aspects, FIG. **12** illustrates a circuit schematic for the preferred embodiment of the present invention. An application specific integrated circuit ("ASIC"), **30**, is designed to receive data from the infrared detector assembly **24** (S1) and the ultrasound detector **26** (S2). The ASIC processes the data by controlling a commercially available microprocessor **32**, and produces outputs to the Inhibit line at pin **28**, the vehicle on-board computer system data bus, J1850, at pin **27**, and the Diagnostic line at pin **26**. The ASIC controls ultrasound transmission by modulating an "on" or "off" voltage through pin **20** of the ASIC to the transistor, **34**. The transistor in turn is turned on for a short time period to allow current to flow through the primary winding of the transformer T1, which creates a current flow through the secondary winding of the transformer. The current flows to the transducer **27**, which in turn transmits an ultrasonic pulse. The returning ultrasonic signals are received by the transducer **27** and returned to pin **19** of the ASIC. Infrared signals from the two IR detectors **21*a***, **21*b*** (FIG. **9**) of unit **24** (S1) are received through pins **22** and **21** of the ASIC.

The incoming signals are amplified and filtered via capacitors, C5 and C6. The ASIC embodies an algorithm in its hardware and software in memory to process the signals and uses a commercially available micro-controller, **32**, to do the calculations. The resulting output is transmitted via the inhibit line to the air bag controller, The ASIC also provides a diagnostic signal regarding the integrity of the sensor system through pin **26** of the ASIC to the air bag controller (ABC **2** FIG. **1**) and the vehicle's indicator panel **28** (FIG. **1**). In the event of a system failure, the air bag controller defaults to the air bag enable state. The ASIC may receive inputs from the vehicle's on-board computer system **3** (FIG. **1**) through the J1850 data bus, the J1850, regarding the various system conditions and environmental conditions which may allow the sensor system to consider certain environmental factors and vehicle conditions in its overall calculations. The ASIC can also transmit to the vehicle's standard on-board computer its status or output. The ASIC provides an oscillating clock signal to the rest of the board through pin **16**.

The ASIC functional description is illustrated in FIG. **13**. Although the preferred embodiment is to have one ASIC chip, the described functions may be contained in two or more ASIC chips. The ASIC contains a J1850 Bus Interface **40**, Analog Outputs **42**, a Non-Volatile RAM **44**, a Digital I/O RAM **46**, a Clock Generator & Precision Oscillator **48**, and a Timing & Control subsystem **49**. The Digital I/O RAM **46** provides AGC (automatic gain control) **51** and BIAS to AC Gain **53*a***, **53*b*** and DC Gain **54*a***, **54*b*** in the processing of infrared signals, and Ultrasound Control to an Ultrasound Transmit Control **56** in the control of ultrasound through pin **20**. The Timing & Control subsystem **49** harmonizes the processing of data among an IR Feature Processor & FIFO **57**, a US Feature Processor & FIFO **58**, a US Detection **59**, a US Xmit Control **56**, and the Digital I/O Ram **46**.

There are two infrared inputs and they are processed in the same manner. The DC Gain **54*a***, **54*b*** detects and accumulates infrared signals to allow level detection by the Level Detector **60*a***, **60*b***. The fluctuating portion of the infrared signal is sent to the AC Gain **53*a***, **53*b*** for motion detection and sent to the Motion Detector **61*a***, **61*b***. The Level Detector **60** determines the amplitude and sends the information to the IR Feature Processor & FIFO **57**. The AC Gain block **53** filters the fluctuating signal with the assistance of a capacitor (C5 or C6) and sends the data to a Motion Detector **61**, which sends the processed data to the IR Feature Processor

& FIFO 57. The IR Feature Processor & FIFO produces IR Features 62.

The ultrasound signal is received through pin 19, amplified and filtered by a Gain & Filter 63, and sent to the US Detector 59. The magnitude 64 and range 65 is extracted from the ultrasound data and sent to the US Feature Processor & FIFO 58, which produces US Features 67. Both the IR Features 62 and US Features 67 are sent to the Feature Combination Processor 66 to produce Fused Features 68.

The IR Features 62, US Features 67, and Fused Features 68 are sent to the Digital I/O Ram block 46 for processing. The Digital I/O Ram 46 accesses a micro-controller through pins 2 through 14 of the ASIC (FIG. 12) to do the necessary calculations to process the data, and it accesses the Non-Volatile Ram 44 for information. The results are sent out via the Bus Interface 40 and the Analog Outputs 42.

In operation, the detection process is generally as follows: Incoming IR and US signals in a given interrogation time-period are analyzed for features (or characteristics) such as motion, frequency of motion, level of motion, temperature level, distance of objects, increasing or decreasing trends, and so on. There is a set of features for the infrared signals and a set of features for the ultrasound signal. Certain features from each set are combined ("fused") to produce a third set of fused features. Each of the three sets, or vectors, are compared to a predetermine matrix of confidence levels and empirical relationships to determine a just-sensed feature state. A feature state is one of the five possible states described above and is the state determined by the sensor system for this interrogation period. The just-sensed feature state is compared to the current state. The current state is one of the five states discussed above, and is what the sensor system indicates is the actual (near present) condition of the passenger seat. If the just-sensed feature state and the current state are different, a set of criteria is used to determine if the feature state should become the current state. The current state determines whether a disenable or interrupt signal should or should not be sent to the air bag controller.

Confidence levels, or the confidence criteria matrix, are determined as follows: Confidence levels are data obtained from analytical and empirical studies of predetermined known possible passenger seat scenarios. Each such scenario is enacted in the passenger seat under a variety of conditions, and features are obtained and analyzed, Some of the features are fused to obtain fused features. Generally, a confidence level is assigned to each feature and state combination. For example, in the presently preferred embodiment, five confidence levels are used for most features. Some of the features are not good indicators of some of the states for certain scenarios so these particular features have reduced or zero confidence levels for those states.

In more detail, from each scenario, there is a set of infrared features and ultrasound features (or appropriate readings from additional sensors, or from other types of sensors, if used). These features from each scenario are compared to features from other scenarios. After examining all of these scenarios and their features, values are assigned to each feature for each state. These values are called confidence levels, and they are assigned according to the feature's strength in indicating the particular state. For example, in the case of a thermal level (quantitative amount) feature from the infrared sensor, five confidence levels from 1 to 5, with 1 being low confidence and 5 being high confidence, may be conveniently assigned this feature's possible values. After examining thermal level features from all the scenarios, the following observations are made: A thermal level of 1 (low thermal level) is a strong indicator of both the IO state and Empty state; at the same time it is a medium indicator of both the OOP state and RFCS state, and a weak indicator of the Occupant state. A thermal level of 3 (medium thermal level) would perhaps be a high indicator of the RFCS state and OOP state, a medium indicator of the Occupant state, and a weak indicator of the IO state and Empty state; A thermal level of 5 (high thermal level) would be a high indicator of the Occupant state, a medium indicator of the OOP state and RFCS state, and a weak indicator of the Empty state and the IO state. After examining this feature, confidence levels are assigned according to the strength of the indicators for each of the states. Through this process, all of the features are assigned confidence levels. Note that some of the features may be combined ("fused") to provide additional information about the scenarios and confidence levels are assigned to the fused features as well.

Conceptually, these confidence levels are placed in a two dimensional matrix with rows and columns, the columns being the features or fused features and the rows being the states. This matrix is referred-to as the confidence criteria matrix.

In examining all the features and scenarios, empirical relationships can be deduced between the confidence levels developed from the feature and state combinations, and sets of empirical formulas can be derived to convert the confidence levels to probability values for each of the states. More specifically, in the empirical studies all the related features are gathered and analyzed for that state. The inter-relationship(s) of the confidence levels for the features are analyzed to determine how they are related in order to produce a high probability value for a particular state. From this examination, the empirical formulas are determined for this state. Then, using this set of empirically-derived formulas in actual (real-time) scenarios, a probability value (or confidence level) is obtained for the state. A set of formulas is derived for each of the states. A confidence criteria matrix and sets of empirical formulas are developed for each model of vehicle because of the variations in the interior area and passenger seat configuration for each of the vehicles.

In FIG. 14, a signal processing functional block diagram for the preferred embodiment of the present invention is illustrated. Infrared raw data from each of the detectors 21*a*, 21*b* (FIG. 9) from the Infrared Sensor 24 (IR 1 Raw Data 70 and IR 2 Raw Data 71) are processed through Infrared Feature Processing 74, which produces an Infrared Feature Vector (A') 76. Similarly, Ultrasound Raw Data 75 from the Ultrasound Transducer 26 are processed through Ultrasound Feature Processing 77, which produces an Ultrasound Feature Vector (B') 88. The ultrasound Transducer can also transmit an ultrasonic pulse via the Ultrasound Transmit Pulse Timing & Control 87. A subset of the Infrared Feature Vector (A") 78 and a subset of the Ultrasound Feature Vector (B") 79 are processed through Fused Feature Processing 80, which produces a Fused Feature Vector (C') 81. These three vectors, Infrared Feature Vector, Ultrasound Feature Vector, and Fused Feature Vector are processed by Detection Processing 82, which produces a Feature State (D') 83. The Feature State is processed by Decision Processing 84 with inputs F" from a Diagnostic Controller 86, and the Feature State is evaluated to determine a Current State (E') 85. Depending on the Current State, a signal disenabling the air bag may be sent to the air bag controller as shown. The Diagnostic Controller 86 also indicates via F^1 system health of the sensor system e.g. ok or malfunction, and in the latter case the air bag is enabled.

Sets of features are extracted from the signals for the given interrogation period. In FIG. 15*a*, the Infrared Feature Processor **74**, raw infrared data is digitized by a Digitizer **100** with reference to Gain Calibration Data **101** obtained at the start-up of the vehicle and stored in Memory **102**. Gain Calibration Data is used to calibrate sensor readings. From this digitized raw data, the frequency of the lateral motion of object or objects in the passenger seat is extracted and is calculated by a Frequency Processor **104** to obtain an IR 1 Lateral Motion Frequency component **106**. From the same digitized raw data, the thermal level of the object at the passenger seat is converted to one of the predetermined levels by a Comparator **108** to obtain an Infrared 1 Thermal Level component **110**. The predetermined levels are levels that correspondingly group analog signal values to a set of discrete n-equal levels. This component is compared against previously obtained thermal levels stored in Memory **112** by a Temporal Processor **114** to determine the trend of the thermal level (increasing or decreasing thermal level), and produces an Infrared 1 Thermal Temporal component **116**. The digitized raw data is also filtered by a Pre-Filter **118** to enhance motion property of the data, and the data is compared to predetermined levels of motion by using a Comparator **120** and an Infrared Lateral Motion Level component **122** is determined. This component is compared by a Temporal Processor **126** against previously obtained motion levels stored in Memory **124** to determine the trend of the motion level, an Infrared Lateral Motion Temporal component **128**.

Raw data from the second detector is processed in the same manner to obtain an IR 2 Lateral Motion Level component **130**, an IR 2 Lateral Motion Temporal component **132**, an IR 2 Thermal Level component **134**, an IR 2 Thermal Temporal component **136**, and an IR 2 Lateral Motion Frequency component **138**.

The motion levels from the two infrared detectors are correlated by a Motion Correlator **140** to determine a Longitudinal Motion Level component **142**, which shows any longitudinal motion of the occupant. The longitudinal information obtained from each detector is contrasted against each other to obtain an Infrared Differential Longitudinal Motion Level component **144**, which is significant when there is motion from one detector but not from the other detector. This component is compared by a Temporal Processor **148** against previously obtained components stored in Memory **146** to determine the trend of the motion level or an Infrared Differential Motion Temporal component **150**. The frequency of the longitudinal motion of the occupant is calculated by a Frequency Processor **152** to obtain an Infrared Differential Motion Frequency component **154**. The Infrared Feature Vector (A') **76** is comprised of the above described infrared components, while only features **106**, **110**, **128**, **154**, **132**, **134** and **138** are used to form the IR Feature Vector subset A", **78**.

Now referring to FIG. 15*b*, which illustrate the Ultrasound Feature Processor **77**, when an ultrasound pulse is transmitted to the targeted area, the ultrasound transducer may receive several ultrasonic returns shortly after the pulse bounces off several objects. These returns are digitized by a Digitizer **160** with reference to Ultrasound Calibration Data **163** obtained at the start-up of the vehicle and stored in Memory **162**. Each of these returns will have a point in time when the return first begins, called an edge, which is detected by an Edge Detector **164**. And each of the returns will have a point in time when its amplitude is at the highest level (or peak level) and this point in time is detected by a Peak Detector **166**. The amplitude is compared to predetermined levels by a Comparator **168** to obtain return levels. From the edge and peak level time of the returns, Absolute Ranges **170** (or distances) of the objects from the sensor unit are determined. The first return from the transmitted pulse usually indicates the object of interest in the passenger seat area and is the First Return Level component **176**. The trend (increasing or decreasing) of the First Return Level component is the First Return Level Rate of Change component **174**, which is determined with reference to previous return levels stored in Memory **172**. The Absolute Range—First Return component **178** is the absolute distance of the first object from the sensor. The rate of movement of all the returns from one pulse is the Range Motion component **180** found by using a Differentiator **182**, and the rate of movement of the Range Motion component is the Range Motion Rate of Change component **184** found by using a Differentiator **186**. Range Motion shows the radial component of motion and vibration of an object. The trend of Range Motion, faster or slower over time, is the Range Motion Temporal component **188** determined with reference to previous range motion values stored in Memory **190** and by using a Temporal Processor **192**. The frequency of Range Motion is the Range Motion Frequency component **194** determined by a Frequency Processor **196**. The relative values between the returns are determined by a Range Correlator **198** to find Relative Range Values components **200**, the corresponding levels or the Relative Range Levels components **202**, and the trend of Relative Range Levels or the Relative Range Levels Rate of Change component **204**, which is determined by a Differentiator **206**.

The relative range level components tend to indicate how objects change in relation to each other and may indicate movement of the object in interest. The range motion components indicate whether there is a constant frequency of movement which would tend to indicate an inanimate object, e.g. a vibration or flutter, or if there are random movements which would tend to indicate an occupant.

The Multipath Triangulation component **208** is where the ultrasonic pulse bounces off several objects before it is received by the transducer, and this value is compared by the Range Correlator **210** to the Range Calibration Data **162** obtained at the start-up of the vehicle. This component is helpful in determining whether there is clarity in the scene being scanned. If this component's value is low, it tends to indicate clarity in the scene and a corresponding high confidence in the scan. If this component's value is high, it tends to indicate confusion in the scene and a corresponding low confidence in the scan. The Air Temperature **212** is obtained from the fact that the air is denser at lower temperature than higher temperature, and there is a faster rate of return of the signal at lower temperature because it transmits through denser air. The Ultrasound Feature Vector (B') **88** is comprised of all of the above described ultrasound components, while the ultrasound feature vector subset comprises features **170**, **178**, **188**, **194**, **200** and **208** only.

Now, referring to block C in FIG. 16, the Fused Feature Processing **80**, a subset of the Infrared Feature Vector (A") **78** comprises the IR 1,2 Differential Motion Frequency component **144**, the IR 1 Lateral Motion Frequency component **106**, the IR 2 Lateral Motion Frequency component **138**, the IR 1 Thermal Level component **110**, the IR 2 Thermal Level component **134**, the IR 1 Lateral Motion Temporal component **128**, and the IR 2 Lateral Motion Temporal component **132**. A subset of the Ultrasound Feature Vectors (B") **79** for this embodiment comprise the Absolute Ranges components **170**, the Absolute Range—1st Return component **178**, the Multipath Triangulation com-

ponent **208**, the Relative Range Values components **200**, the Range Motion Temporal component **128**, and the Range Motion Frequency component **194**. The two subsets are used to extract fused features components for the Fused Feature Vector (C') **81**. Infrared Spatial Frequency Components **300** are sets of distance, frequency, and levels of the objects calculated by the Spatial Correlation Processor **302**, which determines the distance, frequency of movement, and size of the objects detected by the two sensors. The IR **1** Absolute Surface Temperature component **304**, the IR **2** Absolute Surface Temperature component **306**, and the IR Differential Absolute Surface Temperature component **308** are, respectively, temperatures and the difference in temperature found by using the Temperature Processor **310**. The Infrared/Ultrasound Motion Level Correlation component **312**, the Infrared/Ultrasound Motion Level Temporal Correlation component **314**, and the Infrared/Ultrasound Frequency Correlation component **316** are levels of movement, the trend of the movement (slower or faster), and the frequency of movement as determined by the Correlation Processor block **318**. Note, all components of the Fused Feature Vector (C') **81** are calculated by fusing features from both the infrared and ultrasound sensors.

Now referring to FIG. **17**, depicting the Detection Processor **82**, each of the vectors is processed by its own respective feature confidence processor and confidence criteria matrix. The feature components are processed individually and some of the feature components are fused for processing. Referring first to Infrared Feature Vector processing, the components, individual or fused, of the Infrared Feature Vector (A') **76** are processed by an Infrared Feature And Infrared Feature Fusion confidence Processor **400**. In processing the components, references are made to an Infrared Confidence Criteria Matrix stored in Memory **402**, which is modified by previously processed data stored in a History Buffer **404**. This process produces an Infrared Feature Detection and Confidence Matrix **406**, which is processed by an Infrared **1st** Level Fusion Detection Processor **408** to produce an Infrared Detect Decision Confidence Vector **410**. The Infrared/Ultrasound Detect Decision Confidence Vector **412** and the Ultrasound Detect Decision Confidence Vector **414** are produced in the same manner with their respective processing blocks, history buffers, and memory.

The Detection Fusion Processor **416**, with reference to previously processed data stored in its History Buffer **418** and by using empirical formulas and relationships between and among the three detect decision confidence vectors (described above), produces a Feature State (D') **83**. A Feature State is one of the states previously mentioned: Occupant state, Empty state, RFCS state, OOP state, and IO state.

The three vectors, Infrared Feature Vector (A') **76**, Ultrasound Feature Vector (B') **88**, and Fused Feature Vector (C') **81**, are used to produce a Feature State (D') **83** as follows: Using the Infrared Feature Vector as an example, let Infrared Feature Vector={IRF1, IRF2, IRF3, . . . , IRF14}, where each of the IRF#represents a component, and where the Infrared Feature Vector has fourteen vector components (as shown in FIG. **18**). In processing the components of the Infrared Feature Vector, the confidence processor (e.g. Infrared Feature and Infrared Feature Fusion Confidence Processor **400**) refers to a confidence criteria matrix (e.g. Infrared Confidence Criteria Matrix **402**), which is data empirically developed through testing under various conditions and scenarios, as described above. The confidence criteria matrix contains the confidence levels, which may be and are usually modified by previously processed data. The confidence levels indicate the likelihood of the states for the given feature component values. For each pertinent feature component or fused feature component, there is a set of confidence levels for each state.

For example, referring now to FIG. **18**, for a particular Infrared Feature Vector Component ("IRFi") and states, an IRFi component value of 5 has an associated confidence level of 1.3 for the RFCS state, a confidence level of 1.3 for the OOP state, and confidence level of 0 for other states. For an IRFi value of 9, it has a confidence level of 3.3 for the IO state and 0 for other states. The confidence levels may be modified by previously processed vectors stored in the History Buffer, and may be modified to account for environmental and other changes. For example, should recent history show that the vehicle interior has changing thermal characteristics, e.g. starting the vehicle in cold weather with heater on full blast and later maintaining a consistent and warm temperature, the confidence criteria matrix is adjusted to account for this change. Since there is an overall higher thermal level in the vehicle, a higher thermal level is required to indicate the presence of occupants or their movement. Thus, over time, the confidence level for each of the states may vary. FIG. **19** shows a plot of the confidence level for one state of a particular vector component changing over time.

There are also fused features confidence levels, where two or more vector components can indicate confidence levels for the states. For example, in referring to FIG. **20**, an IRF5 value of 1.2 and an IRF1 value of 1.2 would result in a high confidence value for the OOP state and 0 for other states; an IRF5 value of 3 and an IRF1 value of 1 will have a confidence level of 0 for all the states; and an IRF5 value of 2 and an IRF1 value of 3.3 will have a low confidence value for the RFCS state and 0 for other states. For each feature vector, there are a number of these possible fused vector components and their associated confidence levels. The output of the feature and fused feature processing block is a matrix, called the detection and confidence matrix (e.g. Infrared Feature Detection and Confidence Matrix), shown graphically in FIG. **21**. Note that a fused vector may fuse two or more feature vector components.

The Infrared Feature Detection and Confidence Matrix **406** (FIG. **17**) is input to the Infrared **1st** Level Fusion Detection Processor **408**. In the previous step, confidence level calculations provide each individual Infrared feature or fused features with its own detection 'decision'. These individual decisions are now factored together by state in empirically derived functional relationships and formulas, as described above, i.e.:

IR confidence (RFCS)=Function of {IRF1(RFCS), IRF2(RFCS), . . . IRFn(RFCS), IRF3,4,5(RFCS), IRF1,10,11 (RFCS), IRF8,12(RFCS), . . . };

IR confidence (Occupied)=Function of {IRF1(Occupied), IRF2 (Occupied), . . . , IRF8,12 (Occupied), . . . };

IR confidence (OOP)=Function of {IRF1(OOP), IRF2 (OOP), . . . , IRF9,11 (OOP), . . . };

IR confidence (IA)=Function of {IRF1(IA), IRF2 (IA), . . . , IRF8,12 (IA), . . . }; and

IR confidence (Empty)=Function of {IRF1(Empty), IRF2 (Empty), . . . , IRF9,11 (Empty), . . . }.

Each of the above functional relationship will produce a value which indicates the confidence level (or probability value) for the associated state. The output of this process is a vector, called detect decision confidence vector (e.g. Infrared Detection Decisions Confidence Vector **410** in FIG.

17), where each state has an associated confidence value. An example of the Detect Decision Confidence Vector is: Infrared Detection Decision Confidence Vector ={OOP state: 0.02, Empty state: 0.90, RFCS state: 0.04, IO state: 0.0, Occupant state: 0.20}. In the same fashion, the Ultrasound Detect Decision Confidence Vector 414 is produced from the Ultrasound Feature Vector 88, and the Infrared/Ultrasound Detect Decision Confidence Vector is produced from the Fused Feature Vector 81.

Continuing in reference to FIG. 17, these three independent detect decision confidence vectors, Infrared 410, Infrared/Ultrasound 412, and Ultrasound 414, are inputs to a Detection Fusion Processor 416, which produces a Feature State 83. The manner in which the Feature State decision is arrived at includes weighing functions associated with each confidence vector and weighting of recent decision history stored in a History Buffer 418. For example, in the case of an RFCS, from analytical and empirical studies, we have found that the infrared feature is a "weak" indicator, the ultrasound feature is a "strong" indicator, and the combined infrared/ultrasound fused feature is a "moderately strong" indicator. With these three features, more weight will be applied to an ultrasound declared RFCS state, less weight will be applied to the fused feature declared RFCS state, and even less weight to a infrared declared RFCS state. In this fashion, the three detect decision vectors, the IR Detect Decision Confidence Vector, the US Detect Decision Confidence Vector, The IR/US Detect Decision Vector, are weighed and combined to produce a single vector with a corresponding confidence value for each of the states. The state with highest confidence value is selected as the feature state.

To summarize Feature state processing, by using the feature vector and the time-adjusted confidence criteria matrix as input, the processor performs essentially a look-up table function for the confidence levels on each vector component or fused vector component for each state. In this manner, decision making is made independently at the infrared, ultrasound, and infrared/ultrasound feature level. Furthermore, in this process, some features do not provide information on some of the states because these features alone are not dependable to make correct decisions for these states. Although some features are not reliable to make correct decisions for some of the states, in combination, these features are reliable to cover all the states, and this is the power behind the use of multiple feature fusion from the different sensors.

Note the above described preferred process involves first extracting features from raw sensory data, then producing fused features, associating confidence levels with the features and fused features to produce confidence levels for the predefined states, and determining a feature state from the confidence levels of the states. This process employs fusion at the feature level and at the detection level; it is not simple error correction routines. Other fusion methods can be employed within the principles of the present invention. An algorithm can also be used under certain circumstances to fuse the raw sensory data before any feature is extracted. An algorithm can be employed to extract features and produce a feature state from all the features extracted. Similarly, an algorithm can be utilized to extract features from each sensor, produce a state for each sensor, and fuse the states to produce a feature state. In other words, fusion of data can be done at the raw data level, feature level, decision level, or combination thereof, and any one of the above algorithm or combination thereof can be used for the present invention. The preferred embodiment utilizes a combination of fusion at the feature level and at the detection level, and the empirical comparison studies demonstrate this preferred combination provides superior accuracy in detection and discrimination for highly reliable decision.

Referring now to Decision Processing 84 (E) in FIGS. 14 and 22, the Decision Confidence Processor 500 compares the Feature State (D') against a Current State 502, State Change Criteria 503 stored in Memory 504, a History Buffer 506, and a System Health Status Buffer 508. The Current State is the state condition as determined by the sensor system, i.e. what the sensor system indicates is the state of the passenger seat, and the corresponding signal to maintain an enable or disenable signal to the air bag controller. If the presently sensed Feature State is the same as the Current State, the Current State is not changed and the History Buffer store the Feature State. If the Feature State is different from the Current State, the Decision Confidence Processor determines whether the Feature State should become the Current State. For the Current State to become the Feature State, it must satisfy the State Change Criteria stored in Memory, which is a set of predetermined criteria to ensure the highest level of safety and reliability in the decision to enable or disenable air bag deployment. The set of predetermined criteria generally requires that more confirmations be made before changing from a deployment state to a non-deployment state, and less confirmations be made in going from a non-deployment state to a deployment state. The Decision Confidence Processor also looks at the history (since start-up of the vehicle) of the Current States stored in the History Buffer and considers what Current State decisions has been made and how often has the Current State been changed. The History Buffer is updated by the Decision Confidence Processor.

In addition, a Diagnostic Controller 510 checks sensor system integrity and updates the System Health Status Buffer. The Diagnostic Controller provides a System Health 512 indicator to the air bag controller and the vehicle's indicator panel. In case of system failure, the air bag controller defaults to the air bag deployment condition, e.g., by not sending an interrupt to the air bag controller. The Decision Confidence Processor checks the System Health Status Buffer and the other system conditions to ensure the sensor system is functioning properly.

As an example of a state change decision process, if the Current State is the Empty state with the corresponding signal to disenable the air bag and the Feature State is the Occupant state, the Decision Confidence Processor will check the System Health Status Buffer to ensure proper system integrity. It will also check the History Buffer to see how many of the previous consecutive periods has the Feature State been the Occupant state or how often has the Current State been changed. The Decision Confidence Processor will change the Current State from Empty state to Occupant state if, during the last two periods, for example, the Feature State has been the Occupant state. On the other hand, if the Current State has been the Occupant state, it will take much more than two periods to change the Current State from the Occupant state to the Empty state. If the current state has been changed quite a few times previously, it will be increasingly more difficult to change the current state from occupant to empty state. This is because the preferred embodiment biases decisions regarding state change toward safety.

FIG. 23 shows, in the case of detecting a front facing occupant and permitting the air bag to deploy, while inhibiting deployment if an RFCS is detected, that the dual sensor system of the invention provides very high functional reli-

ability. The reliability, R, of 0.98 (98%) or greater is obtained using sensor fusion even where the probability of detection P_D, for Sensor 1 is as low as 0.3 and the probability of false detection, P_{FA}, is as high as 10^{-4} (R of 0.27), single Sensor 2 has a P_D of 0.99 and P_{FA} is 10^{-6}.

The AOS of this invention can even recognize the vehicle it is in by measuring the relative position of the module and the interior attributes of the vehicle. FIG. **24***a* shows actual measurements performed by the above-described AOS system in a Chrysler LH vehicle. The scope trace shows the actual time referenced acoustic returns from the test vehicle, the layout of which is shown in FIG. **24***b*. FIG. **25***a* shows actual measurements performed in a 1989 Dodge pickup truck of layout shown in FIG. **25***b*. Table 1 below shows the actual timing values measured by the AOS system. These results show a signal margin of 1060 μs at the IP measurement mark, 257 μs at the seat position mark and 543 μs at the floor mark. The total time difference is 1860 μs. With a time resolution of better than 20 μs, the AOS has a large signal processing margin when identifying the difference between vehicles such as a Chrysler LH and RAM truck. Comparison of the traces of FIGS. **24***a* and **25***a* show the unique signatures of the vehicle interior configurations by which the AOS of this invention can recognize the vehicle, and a normal state thereof.

TABLE 1

	LH	TRUCK
IP Return	2804 μs	3864 μs
Seat Return	5297 μs	5040 μs
Floor Return	6933 μs	7476 μs

we have measured several types of significant data to evaluate the potential performance of the AOS. This data shows excellent signal to noise ratios (SNR) and a large design performance margin from the sensor suite. The signal to noise values and resulting predicted performance are summarized in FIG. **26**. The Pd numbers in FIG. **26** were calculated using the 4-feature fused probability equation shown below.

$$R_{1,2,3,4}=R_1+R_2+R_3+R_4-R_1(R_2+R_3+R_4)-R_2(R_3+R_4)-R_3R_4+R_1(R_2R_4+R_3R_4)+R_2(R_3R_4+R_1R_3)-R_1R_2R_3R_4$$

The individual probability inputs to the equation were derived from actual measurements and worst case analysis.

Testing conducted on typical IR detectors yielded SNR in the range of 12:1 from a normal occupant in an 83° F. vehicle. The ultrasound sensor yields a SNR of 16:1 during the same type of test. By way of comparison, the ultrasound sensor return from a rear facing child seat was measured with the RFCS both uncovered and covered with two wool blankets. The child seat was a Century brand and was placed in a 1993 Eagle Vision. The uncovered child seat gave an SNR of 20:1 while the seat covered under two blankets generated a SNR of 11:1. These signal traces are shown in FIGS. **27***a* and **27***b*, respectively. This data indicates that the system of the invention can easily discriminate even between these two subtly different occupant states.

The measurements reflected in FIGS. **22**–**27** were taken under static conditions in the laboratory. Assuming that under worst case conditions, the signals would be degraded by about a factor of 4, all SNR data was divided by 4. With only small gains in signal processing, the data was increased by a factor of 2. This small signal processing gain does not include using any adaptive thresholding or historical inputs in the detection process which are standard techniques that can provide substantially increased signal processing gain. Because this is a worst case analysis, such adaptive and historical gains are not included.

Using the adjusted worst case system performance numbers, detection probabilities for each sensing mode were calculated. The calculation assumptions used here were simple envelope detection using fixed thresholds in a Gaussian noise distribution, whereas the AOS of the invention uses more sophisticated detection processes and has higher individual detection probabilities to ensure adequate Pd under all conditions. The individual sensor mode detection probabilities are shown in FIG. **26**, and were used to calculate the fused detection probability shown in the right hand column of FIG. **26**. For this analysis a life of 15 million cycles was assumed. The probability of false alarm for this analysis was set at one in a million cycles. The false alarm probability will be reduced to an even smaller number when history and adaptive processing gains are considered. Not including these gains shows worst case system performance.

Diagnostic reliability also benefits from multi-sensor fusion much the same way that detection benefits. As shown in FIG. **26** when each sensor diagnostic probability is fused, the resultant system diagnostic probability is increased. As was done for the detection analysis, the diagnostic probability numbers began as lab measurements that were adjusted downward for worst case conditions., then adjusted for worst case signal processing gain. These individual probabilities were taken from Gaussian noise and a false alarm rate of one in a 100 million cycles.

Both IP (Instrument Panel or Dashboard) and overhead locations were evaluated and tested for operability. High reliability occupant and rear facing child seat detection can be performed from both the IP and the overhead position. Both the IR and the ultrasonic sensor performance has been determined to be location independent.

The overhead sensor position offers system performance advantages over the instrument panel (IP) mounting position. The overhead position is much harder to intentionally block by normal occupant behavior. In the overhead position, the relative geometry of the vehicle is much more easily measured. This feature allows an overhead mounted AOS to measure the relative position of the IP, the seat and the floor, and determine the type of vehicle the AOS has been placed in.

it should be understood that various modifications within the scope of this invention can be made by one of ordinary skill in the art without departing from the spirit thereof. For example, the memory and history buffers can be used to store the state decision for a predetermined period (say 60 to 600 seconds depending on size of memory supplied in the ASIC or microprocessor) prior to a crash in order to determine what the occupants did prior to or during the crash. Was a dog out of position, a passenger make unusual motions indicative of distractions or intrusions, etc? This may be dumped from time to time into a special memory in a crash "black box" along with other vital vehicle operating data, fuel level, speed, acceleration/deceleration, change of direction, braking, lights and/or wipers-on, interior climate and the like. We therefore wish our invention to be defined by the scope of the appended claims as broadly as the prior art will permit, and in view of the specification if need be.

We claim:

1. A method for determining whether or not to de-activate a vehicle's passenger passive restraint system as a function of a current state value determined by comparing measured signal features to a predetermined set of confidence values and empirical relationships obtained using various known

occupancy scenarios and a set of state change criteria, comprising the steps of:

(a) sensing the characteristics of occupancy of a particular passenger seat within the vehicle using a plurality of sensors functionally associated with said passenger seat and developing a set of corresponding electrical signals;

(b) evaluating said electrical signals to determine a plurality of signal features included in each of said signals;

(c) combining certain ones of said signal features to obtain a plurality of fused features;

(d) associating said signal features and said fused features with the confidence values and empirical relationships to determine a feature state value;

(e) identifying the feature state value as the current state value if the set of state change criteria is met; and

(f) generating a de-activate signal if said current state value is one of a predetermined subset of state values for which said passive restraint system is to be de-activated.

2. A method according to claim 1, wherein said passenger passive restraint system includes an air bag deployment system having an air bag that is located for deployment proximate said passenger seat and that can be de-activated in response to said de-activate signal.

3. A method according to claim 2, wherein said predetermined set of state values includes values corresponding to an empty seat state, an occupied seat state, a rear-facing child seat state, an out-of-position passenger state, and an inanimate object state.

4. A method according to claim 3, wherein:

(a) the occupied seat state corresponds to the scenarios of a person seated in said seat, a person seated in said seat holding a grocery bag, a child in a forward-facing child seat disposed in said seat, a child standing in said seat at a distance from the air bag deployment location, and a pet disposed in said seat;

(b) the rear-facing child seat state corresponds to the scenario of a child in a rear-facing child seat disposed in said seat;

(c) the out-of-position passenger state corresponds to the scenario of a person positioned in close proximity to the air bag deployment location;

(d) the inanimate object state corresponds to the scenario of an inanimate object disposed in said seat; and

(e) the empty seat state corresponds to the scenario of an empty seat.

5. A method according to claim 2, wherein said occupancy scenarios include a person seated in said passenger seat, a person seated in said seat holding a grocery bag, a child in a rear-facing child seat disposed in said seat, a child in a forward-facing child seat disposed in said seat, a child in a forward-facing child seat disposed in said seat, a person positioned in close proximity to the air bag deployment location, a child standing in said seat at a distance from the air bag deployment location, a standing child in close proximity to the air bag deployment location, an empty seat, an inanimate object disposed in said seat, a pet disposed in said seat, and an empty seat.

6. A method according to claim 1, wherein said plurality of sensors is selected from the group consisting of infrared sensors, ultrasound sensors, weight sensors, microwave sensors, light sensors, and laser sensors.

7. A method according to claim 6, wherein said sensing step includes the use of two infrared detectors placed close to each other and separated by a baffle.

8. A method according to claim 7, wherein said sensing step further includes using a multi-element Fresnel lens to focus one detector on a seat back of the passenger seat and to focus the other detector on a seat surface of the passenger seat.

9. A method according to claim 1, wherein said signal features include indicia of (a) motion, (b) frequency of motion, (c) levels of motion, (d) difference in motion levels, (e) distance, (f) relative distance, (g) thermal levels, and (h) difference in thermal levels.

10. A method according to claim 9, wherein said indicia of motion include indicia of lateral notion and longitudinal motion.

11. A method according to claim 1, wherein said fused features include indicia of (a) temperature, (b) temperature differences, (c) approximate size of objects, (d) distance, (e) motion, (f) frequency of motion, and (g) levels of motion.

12. A method according to claim 1, wherein said associating step (d) comprises the substeps of:

i) using predetermined confidence values and said signal features and fused features to produce (1) a decision confidence matrix of confidence values for the signal features of the signals of each sensor, and (2) a decision confidence matrix of confidence values for said fused features;

ii) using the empirical relationships to calculate a decision confidence vector corresponding to each of said decision confidence matrices;

iii) weighing each decision confidence vector in a predetermined manner to produce weighted vectors; and

iv) combining the weighted vectors to produce a resultant vector having state values from which the feature state value is selected.

13. A method according to claim 1, wherein said set of state change criteria includes consideration of previous feature state values and previous current state values.

14. A method according to claim 1, wherein the subset of said predetermined set of state values, for which said passive restraint system is to be de-activated, includes state values corresponding to a rear-facing child seat state, an empty seat state, an inanimate object state, and an out-of-position state.

15. A method according to claim 1, wherein said passive restraint system includes a single canister air bag deployment system.

16. A method according to claim 1, wherein said passive restraint system includes a multi-canister air bag deployment system capable of partially pressurizing an air bag to various degrees of pressure.

17. A method according to claim 12, further comprising modifying said confidence values over time to correspond to changes in environmental conditions of the vehicle.

18. A method according to claim 1, wherein said sensing step includes using an ultrasound sensor to transmit ultrasonic pulses and to receive ultrasonic return signals.

19. A method according to claim 18, further comprising varying the transmission times between said ultrasonic pulses.

20. A method as recited in claim 1, wherein said plurality of sensors include:

(a) a first infrared detector for generating a first raw data signal;

(b) a second infrared detector for generating a second raw data signal; and

(c) an ultrasound detector for generating a third raw data signal; and wherein said evaluating step (b) includes:

i) processing said first and second raw data signals to develop a first set of signals representing a first group of signal features and defining an infrared feature vector signal;

ii) processing said third raw data signal to develop a second set of signals representing a second group of signal features and defining an ultrasound feature vector signal;

iii) selecting a subset of said first group of signal features to develop a third group of signal features defining an infrared feature vector subset signal; and

iv) selecting a subset of said second group of signal features to develop a fourth group of signal features defining an ultrasound feature vector subset signal.

21. A method as recited in claim **20** wherein said combining step includes processing said infrared feature vector subset signal and said ultrasound feature vector subset signal to develop a fused feature vector signal.

22. A method as recited in claim **21**, wherein the processing of said infrared feature vector subset signal and said ultrasound feature vector subset signal includes:

(a) correlating a first subset of said third group of signal features with a first subset of said fourth group of signal features to develop an infrared spatial frequency components signal;

(b) processing a second subset of said third group of signal features with a second subset of said fourth group of signal features to develop an infrared first absolute surface temperature signal, an infrared second absolute surface temperature signal, and an infrared differential absolute surface temperature signal;

(c) processing a third subset of said third group of signal features with a third subset of said fourth group of signal features to develop an infrared/ultrasound motion level correlation signal, an infrared/ultrasound motion level temporal correlation signal, and an infrared/ultrasound motion frequency correlation signal; and

(d) the infrared spatial frequency components signal, the infrared first absolute surface temperature signal, the infrared second absolute surface temperature signal, the infrared differential absolute surface temperature signal, the infrared/ultrasound motion level correlation signal, the infrared/ultrasound motion level temporal correlation signal, and the infrared/ultrasound motion frequency correlation signal are to form said fused feature vector signal.

23. A method as recited in claim **22**, wherein the signals representing the first group of said signal features include a first infrared lateral motion frequency signal, a first infrared thermal temporal signal, a first infrared thermal level signal, a first infrared lateral motion temporal signal, a first infrared lateral motion level signal, an infrared longitudinal motion level signal, an infrared differential motion level signal, an infrared differential motion temporal signal, an infrared differential motion frequency signal, a second infrared lateral motion frequency signal, a second infrared thermal temporal signal, a second infrared thermal level signal, a second infrared lateral motion temporal signal, and a second infrared lateral motion level signal.

24. A method as recited in claim **23**, wherein the signals representing the second group of said signal features include an absolute range signal, a first return level rate of change signal, a first return level signal, an absolute range-1st return signal, a range motion signal, a range motion rate of change signal, a range motion temporal signal, a range motion frequency signal, a relative range level rate of change signal, a relative range level signal, a relative range value signal, a multipath triangulation signal, and an air temperature signal.

25. A method as recited in claim **24**, wherein the signals representing the third group of said signal features include the first infrared lateral motion frequency signal, the first infrared thermal level signal, the first infrared lateral motion temporal signal, the infrared differential motion frequency signal, the second infrared lateral motion frequency signal, the second infrared thermal level signal, the second infrared lateral motion temporal signal, and the infrared differential motion frequency signal.

26. A method as recited in claim **25**, wherein the signals representing the fourth group of said signal features include the absolute range signal, the absolute range-1st return signal, the range motion temporal signal, the range motion frequency signal, the relative range value signal, and the multipath triangulation signal.

27. A method as recited in claim **26**, wherein the signals representing the first subset of said third group includes the first infrared lateral motion frequency signal, the second infrared lateral motion frequency signal, and the infrared differential motion frequency signal.

28. A method as recited in claim **27**, wherein the signals representing second subset of said third group include the first infrared thermal level signal and the second infrared thermal level signal.

29. A method as recited in claim **28**, wherein the signals representing the third subset of said third group include the first infrared lateral motion frequency signal, the second infrared lateral motion frequency signal, the first infrared lateral motion temporal signal, and the second infrared lateral motion temporal signal.

30. A method as recited in claim **29**, wherein the signals representing the first subset of said fourth group include the absolute range signal, the absolute range-1st return signal, the relative range value signal, and the multipath triangulation signal.

31. A method as recited in claim **30**, wherein the signals representing the second subset of said fourth group include the absolute range signal, and the absolute range-1st return signal.

32. A method as recited in claim **31**, wherein the signals representing the third subset of said fourth group include the range motion temporal signal and range motion frequency signal.

33. Apparatus for determining whether or not to control a vehicle's passenger passive restraint system as a function of a current state value determined by comparing measured signal features to a predetermined set of confidence values and empirical relationships obtained using various known occupancy scenarios and a set of state change criteria, comprising:

(a) means for sensing the characteristics of occupancy of a passenger seat within the vehicle using a plurality of sensors functionally associated with said passenger seat and a set of corresponding electrical signals;

(b) means for evaluating said electrical signals to determine a plurality of signal features included in each of said signals;

(c) means for combining certain ones of said signal features to obtain a plurality of fused features;

(d) means for associating said signal features and said fused features with the confidence values and empirical relationships to determine a feature state value;

(e) means for identifying the feature state value as the current state value if the set of state change criteria is met; and

(f) means for generating a state of control signal if said current state value is one of a predetermined set of state values for which said passive restraint system is to be controlled, including possible deactivation of said restraint system.

34. Apparatus according to claim 33, wherein said passenger passive restraint system includes an air bag deployment system having an air bag that is poised for deployment proximate said passenger 'seat and that can be de-activated or inflation controlled in response to said state of control signal.

35. Apparatus according to claim 34, wherein said predetermined set of state values includes values corresponding to an empty seat state, an occupied seat state, a rear-facing child seat state, an out-of-position passenger state, and an inanimate object state.

36. Apparatus according to claim 35, wherein:

(a) the occupied seat state corresponds to the scenarios of a person seated in said seat, a person seated in said seat holding a grocery bag, a child in a forward-facing child seat disposed in said seat, a child standing in said seat at a distance from the air bag deployment location, and a pet disposed in said seat;

(b) the rear-facing child seat state corresponds to the scenario of a child in a rear-facing child seat disposed in said seat;

(c) the out-of-position passenger state corresponds to the scenario of a person positioned in close proximity to the air bag deployment location;

(d) the inanimate object state corresponds to the scenario of an inanimate object disposed in said seat; and

(e) the empty seat state corresponds to the scenario of an empty seat.

37. Apparatus according to claim 34, wherein said occupancy scenarios include a person seated in said passenger seat, a person seated in said seat holding a grocery bag, a child in a rear-facing child seat disposed in said seat, a child in a forward-facing child seat disposed in said seat, a person positioned in close proximity to the air bag deployment location, a child standing in said seat at a distance from the air bag deployment location, a standing child in close proximity to the air bag deployment location, an empty seat, an inanimate object disposed in said seat, a pet disposed in said seat, and an empty seat.

38. Apparatus according to claim 33, wherein said plurality of sensors is selected from the group consisting of infrared sensors, ultrasound sensors, weight sensors, microwave sensors, light sensors, and laser sensors.

39. Apparatus according to claim 38, wherein said means for sensing includes two infrared detectors placed close to each other and separated by a baffle.

40. Apparatus according to claim 39, wherein said means for sensing further includes a multi-element Fresnel lens for focusing one detector on the seat back of the passenger seat and for focusing the other detector on the seat surface of the passenger seat.

41. Apparatus according to claim 33, wherein said signal features include indicia of (a) motion, (b) frequency of motion, (c) levels of motion, (d) difference in motion levels, (e) distance, (f) relative distance, (g) thermal levels, and (h) difference in thermal levels.

42. Apparatus according to claim 41, wherein said indicia of motion include indicia of lateral motion and longitudinal motion.

43. Apparatus according to claim 33, wherein said fused features include indicia of (a) temperature, (b) temperature differences, (c) approximate size of objects, (d) distance, (e) motion, (f) frequency of motion, and (g) levels of motion.

44. Apparatus according to claim 33, wherein said means for associating comprises:

i) means for using predetermined confidence values and said signal features and fused features to produce (1) a decision confidence matrix of confidence values for the signal features of the signals of each sensor, and 2 a decision confidence matrix of confidence values for said fused features;

ii) means for using the empirical relationships to calculate a decision confidence vector corresponding to each of said decision confidence matrices;

iii) means for weighing each decision confidence vector in a predetermined manner to produce weighted vectors; and

iv) means for combining the weighted vectors to produce a resultant vector having state values from which the feature state value is selected.

45. Apparatus according to claim 33, wherein said set of state change criteria includes consideration of previous feature state values and previous current state values.

46. Apparatus according to claim 33, wherein the subset of said predetermined set of state values, for which said passive restraint system is to be de-activated, includes state values corresponding to a rear-facing child seat state, an empty seat state, an inanimate object state, and an out-of-position state.

47. Apparatus according to claim 33, wherein said passive restraint system includes a single canister air bag deployment system.

48. Apparatus according to claim 33, wherein said passive restraint system includes a multi-canister air bag deployment system capable of partially pressurizing an air bag to various degrees of pressure.

49. Apparatus according to claim 33, further comprising means for modifying said confidence values over time to correspond to changes in environmental conditions of the vehicle.

50. Apparatus according to claim 33, wherein said means for sensing includes an ultrasound sensor for transmitting ultrasonic pulses and for receiving ultrasonic return signals.

51. Apparatus according to claim 50, further comprising means for varying the transmission times between said ultrasonic pulses.

52. Apparatus as recited in claim 33, wherein said plurality of sensors of element (a) include:

i) a first infrared detector for generating a first raw data signal;

ii) a second infrared detector for generating a second raw data signal; and

iii) at least one ultrasound detector for generating at least one third raw data signal; and wherein said means for evaluating (b) includes:

i) means for processing said first and second raw data signals and for developing a first set of signals representing a first group of signal features and defining an infrared feature vector signal;

ii) means for processing said third raw data signal and for developing a second set of signals representing a second group of signal features and defining at least one ultrasound feature vector signal;

iii) means for selecting a subset of said first group of signal features to develop a third group of signal features defining an infrared feature vector subset signal; and

iv) means for selecting a subset of said second group of signal features to develop a fourth group of signal features defining at least one ultrasound feature

vector subset signal.

53. Apparatus as recited in claim 52 wherein said means for combining includes means for processing said infrared feature vector subset signal and said ultrasound feature vector subset signal to develop a fused feature vector signal.

54. Apparatus as recited in claim 53, wherein said means for processing said infrared feature vector subset signal and said ultrasound feature vector subset signal includes

(a) means for correlating a first subset of said third group of signal features with a first subset of said fourth group of signal features and for developing an infrared spatial frequency components signal;

(b) means for processing a second subset of said third group of signal features with a second subset of said fourth group of signal features and for developing an infrared first absolute surface temperature signal, an infrared second absolute surface temperature signal, and an infrared differential absolute surface temperature signal;

(c) means for processing a third subset of said third group of signal features with a third subset of said fourth group of signal features and for developing at least one infrared/ultrasound motion level correlation signal, an infrared/ultrasound motion level temporal correlation signal, and an infrared/ultrasound motion frequency correlation signal; and

(d) the infrared spatial frequency components signal, the infrared first absolute surface temperature signal, the infrared second absolute surface temperature signal, the infrared differential absolute surface temperature signal, the infrared/ultrasound motion level correlation signal, the infrared/ultrasound motion level temporal correlation signal, and the infrared/ultrasound motion frequency correlation signal are combined to form said fused feature vector signal.

55. Apparatus as recited in claim 54, wherein the signals representing the first group of said signal features include a first infrared lateral motion frequency signal, a first infrared thermal temporal signal, a first infrared thermal level signal, a first infrared lateral motion temporal signal, a first infrared lateral motion level signal, an infrared longitudinal motion level signal, an infrared differential motion level signal, an infrared differential motion temporal signal, an infrared differential motion frequency signal, a second infrared lateral motion frequency signal, a second infrared thermal temporal signal, a second infrared thermal level signal, a second infrared lateral motion temporal signal, and a second infrared lateral motion level signal.

56. Apparatus as recited in claim 55, wherein the signals representing the second group of said signal features include an absolute range signal, a first return level rate of change signal, a first return level signal, an absolute range-1st return signal, a range motion signal, a range motion rate of change signal, a range motion temporal signal, a range motion frequency signal, a relative range level rate of change signal, a relative range level signal, a relative range value signal, a multipath triangulation signal, and an air temperature signal.

57. Apparatus as recited in claim 56, wherein the signals representing the third group of said signal features include the first infrared lateral motion frequency signal, the first infrared thermal level signal, the first infrared lateral motion temporal signal, the infrared differential motion frequency signal, the second infrared lateral motion frequency signal, the second infrared thermal level signal, the second infrared lateral motion temporal signal, and the infrared differential motion frequency signal.

58. Apparatus as recited in claim 57, wherein the signals representing the fourth group of said signal features include at least one of: the absolute range signal, the absolute range-1st return signal, the range motion temporal signal, the range motion frequency signal, the relative range value signal, and the multipath triangulation signal.

59. Apparatus as recited in claim 58, wherein the signals representing the first subset of said third group includes the first infrared lateral motion frequency signal, the second infrared lateral motion frequency signal, and the infrared differential motion frequency signal.

60. Apparatus as recited in claim 59, wherein the signals representing second subset of said third group include the first infrared thermal level signal and the second infrared thermal level signal.

61. Apparatus as recited in claim 60, wherein the signals representing the third subset of said third group include the first infrared lateral motion frequency signal, the second infrared lateral motion frequency signal, the first infrared lateral motion temporal signal, and the second infrared lateral motion temporal signal.

62. Apparatus as recited in claim 61, wherein the signals representing the first subset of said fourth group include the absolute range signal, the absolute range-1st return signal, the relative range value signal, and the multipath triangulation signal.

63. Apparatus as recited in claim 62, wherein the signals representing the second subset of said fourth group include the absolute range signal, and the absolute range-1st return signal.

64. Apparatus as recited in claim 63, wherein the signals representing the third subset of said fourth group include the range motion temporal signal and range motion frequency signal.

65. An application specific integrated circuit device for processing sensory input signals received from sensors adapted to sense the characteristics of occupancy of a particular passenger seat within a vehicle, and for determining whether or not to de-activate a vehicle's passenger passive restraint system as a function of a current state value determined by comparing measured signal features to a predetermined set of confidence values and empirical relationships obtained using various known occupancy scenarios and a set of state change criteria, comprising in one or more chips:

(a) means for evaluating said input signals to determine a plurality of signal features;

(b) means for combining certain ones of said signal features to obtain a plurality of fused features;

(c) means for associating said signal features and said fused features with the confidence values and empirical relationships to determine a feature state value;

(d) means for identifying the feature state value as the current state value if the set of state change criteria is met; and

(e) means for generating a de-activate signal if said current state value is one of a predetermined set of state values for which said passive restraint system is to be de-activated.

* * * * *

EXHIBIT C

Comparison of Patents

EXHIBIT C

Comparison of Patents

U.S. Patent No. 5,482,314	U.S. Patent No. 6,272,411
A method for determining whether or not to de-activate a vehicle's passenger passive restraint system as a function of a current state value determined by comparing measured signal features to a predetermined set of confidence values and empirical relationships obtained using various known occupancy scenarios and a set of state change criteria, comprising the steps of:	**The method of operating a vehicle occupancy state sensor system comprising:**
(a) sensing the characteristics of occupancy of a particular passenger seat within the vehicle using a plurality of sensors functionally associated with said passenger seat and developing a set of corresponding electrical signals;	(a) interrogating sensors of said system periodically to provide current data;
(b) evaluating said electrical signals to determine a plurality of signal features included in each of said signals;	(b) comparing current data to a history database to determine if there is a change in occupancy state; and
(c) combining certain ones of said signal features to obtain a plurality of fused features;	(c) providing a signal for an airbag control system if the occupancy state corresponds to a preselected occupancy state criteria for said signal output.
(d) associating said signal features and said fused features with the confidence values and empirical relationships to determine a feature state value;	
(e) identifying the feature state value as the current state value if the set of state change criteria is met; and	
(f) generating a de-activate signal if said current state value is one of a predetermined subset of state values for which said passive restraint system is to be de-activated.	

EXHIBIT M

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